The Welding Engineer

Reg. U. S. Pat. Office

Founded by L. B. Mackenzie, 1916

$3.00 per year in U. S. | 608 S. Dearborn St., Chicago, Ill. | $4.00 per year in Canada and abroad

SEPTEMBER, 1932 | VOL. 17, NO. 9

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The Welding Engineer

Volume 17 | September, 1932 | Number 9

THE WELDING ENGINEER
PUBLISHING CO.

608 S. Dearborn St., Chicago, Ill.

Telephone WEBster 7134

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Published on the 15th of each month. Subscription payable in advance and postage free. United States and possessions, $3 a year; Foreign Countries, $4 a year; Canada, $4 a year; Single copy, domestic, 25 cents; Single copy, foreign, 30 cents. Entered as second-class matter January 20, 1916, at the postoffice at Chicago, Illinois, under the act of March 3, 1879.

Last advertising forms close at 8:00 a. m. on the 12th. To show proof for correction copy must be received at an earlier date and allowances should be made for delay to mails. All copy should be in by the 12th of the month at the latest.

The Welding Engineer does not publish in its news or advertising columns any matter that deals with or refers to either personal or legal controversies.

MEMBER AUDIT BUREAU OF CIRCULATIONS

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Superior from the Cost standpoint, too —

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Welding Rods
and
Electrodes

● *Swedox Service Facilities Include Complete Stocks of All Gas and Arc Welding Accessories.* ●

Because they weld better, SWEDOX Welding Wires keep your welding costs down where they should be. SWEDOX saves right on the job, with smooth, fast operation, uniformly sound welds, and no money wasted doing the work over a second time. Whether it is simple production or the most difficult and intricate welding, SWEDOX quality will pay its own way. Send for our complete welding wire catalog or use our engineering service to help select the wire that will make the best cost showing on your work.

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EDITORIAL

What About the Profit?

MORE business seems to be in prospect for the welding industry as steel production gradually expands. The trunk lines for transmission of natural gas cannot be increased into the contemplated networks of branch lines without giving employment to thousands of welders; the youthful air conditioning industry is thriving on a diet of welded construction; all the plans made for making homes of steel require at least partial assembly by welding; untold numbers of railroad cars in bad condition are due for replacement, and welded construction is making enormous strides in this field; bridge reconstruction, car repair and other large scale salvage work are pointed out as practically new markets; the most conservative men in the industry do not venture to set a limit. This is going to be fine—provided there's a profit in it. If industry as a whole is going to profit by more activity, then each unit must have its chance. This means that industry must keep an eye everlastingly on the purchasing agent and demand of him a knowledge of other things than price—operating costs, for example—and a willingness to let the seller make a fair margin.

The Human Element Remains

UNDER present conditions there is apparently something rather brutal about the occasional mention of eliminating the human element in welding as a result of the development of new appliances, materials and procedures. It is really not as bad as it sounds. For one thing, there are hundreds of welding applications which would not be possible without mechanical methods of maintaining a uniform rate and a precisely uniform technique. So there are automatic controls for all processes. There are also features of the simplest hand welding operations which make it a matter of real hard work to produce a satisfactory weld. Any improvement which releases some of the effort required to get the right result simply makes that effort available for some other use. The unskilled man may be able to do better work as a result of the improvement, but may not the real capable welder make a still better showing? It is difficult to see how he can help it. To quite a large extent the human element has been a real asset in the development of the welding industry. And if aided and encouraged by improvements, it will continue to be an asset.

Makeshifts Are Costly

TRYING to save money by using homemade welding appliances is not good economy and consequently not good business. When a shop is handicapped by having to get along with old and nearly worn out equipment in competition with others which are well equipped, it finds the going plenty hard. It is just that much harder to get results with equipment which was not originally designed to be used for welding. House lighting electric generators and acetylene generators are a temptation to the man who wants to equip at low cost. Some saving can perhaps be made but is practically certain to be lost many times over. In the early days of the industry there was naturally a shortage of equipment and a good deal of improvising was done by men whose interest in welding got ahead of the supply of apparatus. There were mishaps as well as successes, and the mishaps often proved to be stumbling blocks to progress. Let us have no more of these if they can be avoided.

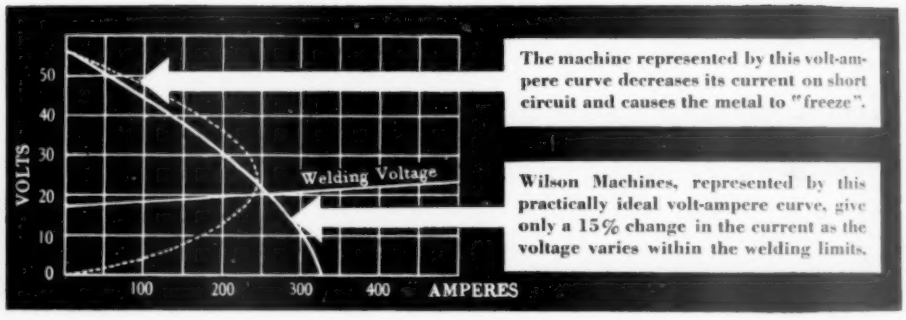
Salvage, Safety and Savings

MACHINERY and plant equipment now standing idle may be wanted in a hurry next month or next week. Now is the time to inspect it and put the welder to work if repairs are needed. Sudden shut-downs, costly delays and injuries to workmen may be the price of postponing repairs until the last minute and then taking a chance that cracked and worn parts will last through the production of one rush order. Safety first is a good enough reason for getting repairs made now. The possibility of saving a lot of money is another good reason. Plant executives should not lose sight of the fact that the welding processes can save fortunes by salvage and rebuilding. One writer has recently shown how great savings can be made by rebuilding cars. This is of real importance to industrial plants, mines, quarries, steel plants and lumber camps owning their own rolling stock. Work of this kind done now with a little capital will save a lot of capital later on when the equipment is wanted for service.

Cats and Dogs

FIRST they fight, then they live together at cross purposes, and then they finally learn to eat peacefully together out of the same dish. A few years ago a tank maker would grudgingly make a welded tank if the customer insisted on it. Now he just rivets when rivets are specified. A good deal of growling and spitting has been done in the period of transition. Peace has not been thoroughly restored but it is fairly obvious that the riveter has become no more obsolete than the ice-man. At this stage a foremost producer of rivets puts on the market a line of welding wire. At this time, also, there are signs of steel foundries adding welderies, either directly or indirectly, without discontinuing the production of castings. In some cases these two departments are sure to have some interesting rounds. But they'll get along all right after become adjusted. They have only to look at the piping field to see the happy ending of the story. In that field the leading makers of cast threaded fittings are now serenely selling fittings made for welding. One by one the barriers go down and the welding processes make their way into new fields. These trends which have been mentioned are the most significant proof obtainable that welded construction has been accepted definitely, not only by its enthusiasts but also by its early opponents. There has been enough controversy to make it interesting, and fur flying here and there, but fortunately not much bloodshed or desolation.

Let Wilson CLOSE CONTROL prevent "frozen" welds



A lack of *close current control* causes a drop in current value when the arc is shortened. As a result, the amperage (heat) is reduced, the puddled metal is cooled, and the arc "freezes". Wilson *close control*, as proved by the volt-ampere curves, gives you correct constant heat over the full welding range—enables you to produce strong, fine-grain welds at *every* welding range. Ask Wilson engineers to tell you about other advantages of *close control*. Wilson Welder & Metals Co. Inc., North Bergen, N. J.

WILSON

ARC-WELDING MACHINES AND WIRE

Copr. 1932, Wilson Welder & Metals Co. Inc.

174th Armory, Buffalo, N. Y., Where the National Metal Exposition Will Be Held.

With the American Welding Society at Buffalo

STARTING Monday afternoon, October 3rd, the technical sessions of the Fall Meeting of the American Welding Society held in connection with the National Metal Congress at Buffalo, N. Y., will furnish to workers and executives in the metal working industries a picture of present practice and future possibilities in the welding industry. The program has been arranged to provide a careful grouping of papers which makes each session a complete unit covering important phases of the industry.

Papers Grouped in Technical Sessions

In the first session, for example, "Fabrication of Heavy Machinery Parts from Rolled Steel" is accompanied by a paper on "Production Cutting." A paper on "Maintenance Welding" is included in this same group. This is logical, because all plants large enough to do fabrication work on a large scale are sure to have a considerable amount of repair work to do. The increasing importance of non-ferrous metals in the welding industry justifies the inclusion of a special session on this topic. The technical papers on other subjects are similarly grouped.

In one of the sessions—that scheduled for Wednesday morning—technical aspects of the subjects are set aside in favor of three discussions of a merchandising nature. At this time attention will be concentrated on methods of popularizing and selling products which have been welded. It is really difficult to understand why so little attention has been given to this subject in the past by manufacturers of welded products. There are a few companies who have made a success of welding and who have continually featured their success in general advertising and in direct advertising for many years. They represent only a small percentage of the total number who might well have followed their example. This discussion is therefore one which should be full of useful ideas for all those who are engaged in production welding.

These are just a few of the high spots. The complete program will be found on the page following. According to the present plan, all of the morning technical sessions will be held in the Statler Hotel at Buffalo, which is the headquarters of the American Welding Society for that week, and all of the afternoon sessions will be held at the 174th Armory, where the National Metal Exposition will also be held.

Executives Are Looking for Modern Methods

In spite of the recent unfavorable business conditions, this event is expected to draw a good attendance. In the first place, the lesson of the past two years has been that no business concern is safe in trying to stand still. In order to keep up with improvements and design and quality, and in order to keep manufacturing costs below the prevailing price levels, it is necessary to watch all plant operations and processes and keep them consistently up-to-date. In the second place, the location of the Exposition is ideal for serving a large territory. In addition to being a large manufacturing city itself, Buffalo is within an overnight ride from all of the important eastern industrial centers and those as far west as Chicago. It is very close to the large steel producing and steel fabricating centers. Good attendance is further encouraged because the National Metal Congress instead of representing a single organization brings together the members of eight important engineering societies, including the American Society for Steel Treating, all of whom are directly or indirectly interested in some phases of welding.

At the Exposition in the 174th Armory, visitors will have a chance to observe many of the things which will be discussed at the meetings. There will also be an opportunity to inspect and have demonstrated some of the latest developments in the manufacture of welding apparatus, materials and supplies.

G. W. SWAN
Secretary-Treasurer Western New York Section, American Welding Society.

PROGRAM

of

Technical Sessions

American Welding Society

Fall Meeting, Buffalo, N. Y.,
Week of October 3rd

Registration Facilities Will Be Provided Throughout the Week from 9:30 a. m. to 5:00 p. m., Commencing Monday, October 3rd.

FRANK P. McKIBBEN
President, American Welding Society.

Monday Afternoon—1:45 P. M.

Presiding officer, G. W. Swan, president, The Engineering Society of Buffalo.

Address of welcome and response.

Monday Afternoon—2:15 P. M.—Technical program.

Presiding officer, F. P. McKibben, president.

"Rolled Steel Designs for the Iron and Steel Industries," Christian A. Wills, William B. Pollock Co.

"Conditioning, Shaping and Machining of Carbon Steel With Oxygen," H. H. Moss.

"Car Scrapping," W. H. Ludington, Air Reduction Sales Co.

Monday Evening—6:30 P. M.

Dinner Meeting, Board of Directors, Statler Hotel.

Tuesday Morning—9:45 A. M.

Presiding office, J. J. Crowe, member, Board of Directors.

Welding of Non-Ferrous Metals

"Welding of Duralumin," representative of Union Carbide and Carbon Research Laboratories.

"Welding of High Nickel Alloys," J. G. Shoener and F. G. Flocke, International Nickel Co.

"Lead Welding," R. L. Ziegfield, Lead Industries Association.

"Influence of a Magnetic Field Parallel to the Iron Arc On Welding," F. R. Hensel and W. A. Maddox, Westinghouse Electric & Manufacturing Co., Research Laboratories.

Tuesday Afternoon—2:00 P. M.

Presiding officer, C. A. Adams, Director, American Bureau of Welding.

Fundamental Research in Welding

"Determination of Internal Stresses In Welds By X-Rays," John T. Norton, Massachusetts Institute of Technology.

"Metal Deposition In Electric Arc Welding," G. E. Doan, Lehigh University.

"Corrosive Fatigue Testing," W. E. Harvey, Lehigh University.

"Tests of Welded Butt-Strap Joints," S. C. Hollister, Purdue University.

Wednesday Morning—9:45 A. M.

Presiding officer, J. B. Tinnon, chairman, National Meetings and Papers Committees.

Merchandising

"The Application of Welding to the Manufacture of Heavy Mechanical Equipment," A. E. Gibson, Wellman Engineering Co.

"Selling Welded Products," T. C. Fetherston, The Linde Air Products Co.

"Popularizing the Welded Product," G. M. Gillen, G. M. Basford Co.

Wednesday Afternoon—2:00 P. M.

Presiding officer, J. G. Lincoln, past chairman, Cleveland Section.

"Pre-Qualification Tests of Welders," E. Lunn, chairman, former Committee on Qualification of Welders.

Discussions of Mr. Lunn's paper by H. E. Rockefeller, Linde Air Products Co., and A. Vogel, General Electric Co.

"Qualification Requirements for Welders," V. P. Marran, Walsh Holyoke Steam Boiler Works.

"The Chemistry of Low Carbon Metal-Arc Weld Metals," J. C. Hodge, Babcock & Wilcox Co.

Discussion of J. C. Hodge's paper by G. R. Brophy, General Electric Co.

Thursday Morning—9:45 P. M.

Presiding officer, E. A. Doyle, past president, American Welding Society.

"Load Test on a Welded Roof Truss," C. H. Jennings, Westinghouse Electric & Manufacturing Co. Research Laboratories.

"Metal Spraying," H. B. Rice, Metal Spray Co.

"Automobile Repair Welding," by A. F. Keogh, Sound Welding Co.

"Thyratron Control for Resistance Welding," W. C. Hutchins, General Electric Co.

Thursday Afternoon—2:00 P. M.

Presiding officer, H. C. Boardman, past chairman, Chicago Section.

"Application of Welding to Pressure Vessels and Metallurgy of Welds," P. R. Hawthorne and J. C. Holmberg, Struthers Wells Co.

"Welding of Pressure Vessels," H. L. R. Whitney, The M. W. Kellogg Co.

"Automatic Welding With Heavy Coated Electrodes," L. R. Leysen, General Electric Co.

Thursday Evening—6:30 P. M.

Annual banquet followed by dancing. Under joint auspices of the American Welding Society and the American Society for Steel Treating, Ball Rom, Hotel Statler.

Friday Morning

Inspection Trip.

What Exhibitors Have to Offer

In the booth of the Air Reduction Sales Company (G-7,9,11) particular attention will be given to the work of recently developed machines for automatic welding and cutting with the oxy-acetylene flame. A number of new machines will be exhibited and some of them demonstrated. The company is also bringing out a new double reduction regulator and will have this new item on display at that time.

The American Brass Company will occupy Booth D-16. The feature of the exhibit will be electric welding of Everdur metal by both the metal and carbon arc methods. C. E. Swift, Welding Engineer, will conduct the demonstrations. Set displays will include Everdur tanks, automatically welded, as well as other specimens of Everdur by both gas and electric methods. There will also be a display of iron castings repair welded with Tobin bronze filler rod. W. H. Dowd, C. E. Swift and A. M. Dinkler will be in attendance.

The American Steel & Wire Company will exhibit Premier welding wire, USS stainless and heat resisting alloy steels, SAE alloy steels, cold rolled strip steel, cold finished steel bars and other wire products. In addition, there will be an actual demonstration of interesting applications of welding. The booth number is E-6.

The Harnischfeger Corporation will have in action a quarter-ton hoist and a 300 amp. and 100 amp. P & H Hansen arc welding machine. This display will give an opportunity for the inspection of several new improvements which have been made in these machines to increase the welding range, improve the stability and increase the compactness of the unit. The exhibit will be a working one so that all of the new features can be demonstrated at the booth. The booth number is F-12, and in attendance there will be G. L. Drake, D. B. Patterson and K. L. Hansen.

The Hollup Corporation will occupy booth C-2 jointly with U.S.L. Battery Corporation, featuring a working demonstration of their newly developed "Sureweld" protected arc electrode. This electrode was developed especially to meet the new code requirements and the display will include test data and test plates as well as the actual operation of the new wire.

In the booth of the Kelly-Koett Mfg. Co., (B-33) those who are interested in welding applications which have to meet rigid code requirements will find considerable information on late developments in the use of X-ray equipment for the inspection of welds.

The Lincoln Electric Company exhibit will be located in booth F-1. It is expected that they will have on display their new "Shield-arc" welder in both 300 and 400 amp. sizes, both sizes operating. There will also be in operation a brand new device for feeding covered electrodes automatically. The wire feeding electronic tornado automatic will be shown and two new devices for obtaining shielded arc welding automatically. In addition to these equipment exhibits and demonstrations, a number of motors will be exhibited; also a complete line of electrodes and supplies for electric arc welding.

The Linde Air Products Company (in D-6 and E-1, 7) will show oxy-acetylene welding and cutting equipment and hard facing materials with information as to important applications.

A demonstration which has not been available at any of the previous expositions is that of the Metallizing Corporation of America, who will exhibit equipment for spraying metal to form a coating on any kind of surface. The rapidly increasing use of special metallic coatings for protective and decorative purposes will be illustrated and explained, and it is expected that the actual operation of the equipment will be demonstrated.

In the booth of John A. Roebling's Sons Company (G-1) the display will consist of the Roebling line of welding wire for oxy-acetylene and electric arc welding, arc welding cable, wire and wire rope and other wire products.

Metal & Thermit Corporation, in booth A25, will show the new method of Thermit welding rails under traffic and the complete line of Murex electrodes for electric arc welding. An operator will be in attendance to demonstrate the uses of these electrodes.

USL Battery Corporation (E 4) will have in operation a new 400 ampere arc welder. Engineers of the company will be in attendance to demonstrate the new machine. There will also be displayed welding electrodes, including a new high speed electrode of the shielded arc type.

The Welding Engineer Publishing Company, in Booth A-30 will have an educational exhibit of welding literature. Members of the staff will be in attendance to assist in selecting literature, arranging instruction courses and general planning of training activities for both schools and industrial plants.

Exhibit space has also been reserved by Eisler Electric Corporation and Wickwire Spencer Steel Corporation. Details of these exhibits were not available at the time of publication.

In addition to these exhibits, which are of special interest on account of their direct application to welding problems, there will be a number of exhibits of manufacturers of ferrous and non-ferrous metals and alloys which will show how these special materials can be welded. There will also be several of the equipment exhibits which demonstrate important applications of welding processes and several exhibits of testing equipment which are of particular value to welding departments at this time.

Good Entertainment Assured

With such a comprehensive program of discussions of welding problems and welding methods, and so many things to observe and investigate at the exposition, there may not be very much leisure time for the visitors. However, arrangements have been made so that what leisure time there is can be put in to good advantage. This has required the cooperation of the parent section of the American Welding Society, the Western New York Section, and the American Society for Steel Treating. Mr. Gideon W. Swan, Sales Agent for John A. Roebling's Sons Co., and President of the Engineering Society of Buffalo, is also Secretary-Treasurer of the Western New York Section of the A.W.S. He has had to assume the principal responsibilities of making arrangements for the meetings and for the entertainment of guests, and has done this work with the energy that has won him the reputation as one of the most active workers of the American Welding Society. Those who attended the Annual Fall Meeting which was held in Buffalo in 1926 will recall the splendid work which was done by the Buffalo Section at that time, and can safely anticipate a successful meeting in Buffalo next month.

Welding Practice for Nickel-Clad Steel Plate*

Taper Bottom Obround Tank, Partially Completed in Shop of James Russell Boiler Works. Size 42"x30"x44". ¼ Inch, 10% Nickel Steel.

By F. P. Huston†

NICKEL-CLAD steel plate is steel plate protected on one side with a dense, homogeneous, sheet of pure nickel. The nickel cladding possesses the same chemical and physical properties as hot rolled or hot forged nickel in other forms. It is firmly and permanently bonded to the steel base plate and will not separate from it under normal conditions of temperature change, pressure, vacuum, or deformation in forming.

The availability of large and thick plates makes possible the construction of massive pressure vessels, evapora-

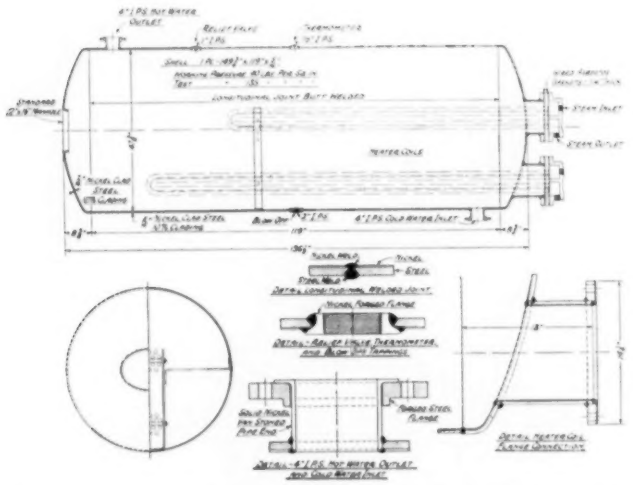


Fig. 1. Detail Drawing of 1000-Gallon Hot Water Heater Tank. $\frac{1}{16}$"—10% Nickel-Clad Steel Shell. $\frac{3}{16}$"—10% Heads. Courtesy Montreal Locomotive Works.

tors, storage tanks, railroad tank cars, and many other types of equipment lined with pure nickel and free from the many disadvantages of thin loose linings, especially in equipment operating under vacuum.

The intimate metallic contact between the two metals gives the clad plate the heat conductivity equal to solid steel or solid nickel plate, and maximum thermal efficiency is obtained in all equipment requiring heat transfer through the wall. The thermal coefficients of expansion of nickel and steel are nearly identical and temperature changes within the range where nickel and steel may be used will not affect the bond.

Physical Properties

The steel of the composite plate is low carbon steel and is regularly furnished, unless otherwise specified, of flange quality, with a nominal tensile strength of 55,000 p.s.i. The nickel contributes an additional strength to the steel plate and, in general, increases the ultimate tensile strength 500 to 5,000 p.s.i. Design data, therefore, follows closely the practice used in designing similar vessels in steel.

The Lukens Steel Company reports the following results of tensile tests:

	Yield Point p.s.i.	Ultimate Tensile Strength p.s.i.	% Elong. in 8"	% Red. of Area
$\frac{3}{16}$ inch plate clad .050" nickel				
Carbon Steel	42,200	51,200	41.75	72.9
Nickel-Clad Steel	45,600	57,500	25.0	52.8
½ inch plate clad .050" nickel				
Carbon Steel	36,800	60,300	27.5	50.7
Nickel-Clad Steel	40,500	60,900	30.0	58.0
$\frac{5}{8}$ inch plate clad .062" nickel				
Carbon Steel	32,900	61,000	26.3	58.8
Nickel-Clad Steel	40,300	61,800	30.0	62.5

The ½ inch and $\frac{5}{8}$ inch tests were from the same melt which had the following ladle analysis:

Carbon	.20
Manganese	.47
Phosphorus	.018
Sulphur	.040

*Extracted from a bulletin "Methods for the Fabrication of Nickel-Clad Steel Plate," by courtesy of the International Nickel Co., New York, N. Y.

†International Nickel Co., New York, N. Y.

The $\frac{3}{16}$ inch tests were from lower carbon steel and the large increase in ultimate tensile strength, and the lower elongation and reduction of area is due to the greater ratio of nickel to steel, and to the work hardening of the nickel in finishing wide plate in this gauge. Annealing the nickel-clad would bring the tensile figures closer together.

Metallic Arc Welding

Heavy steel plate is generally welded by the metallic arc method, and consequently this is the most important method to be considered in welding nickel-clad steel. Most types of welds consist of a steel weld on the one side and a finishing bead of nickel weld on the nickel side. The steel weld is usually laid down first to almost the full section of the plate, plus the required reinforcement. The accustomed practices prevailing in the shop, including size and type of weld rod, current adjustment, and manipulation peculiar to individual operators, are used without important modifications in welding the steel side of the plate. In welding the nickel, however, satisfactory welds are obtained only by adhering to closely defined methods. The operators inexperienced in the welding of nickel should study the instructions distributed by The International Nickel Company on the welding of solid nickel, and they should make welds on properly prepared test pieces to adjust the manipulation to suit the characteristics of nickel welding. The skilled operator will have no difficulty in doing this. The principal points to observe are:

1. The joint must be cleaned free from "icicles," slag, and heavy oxide resulting from welding the steel side. Chipping the seam with a round nosed chisel to a depth slightly greater than the thickness of the cladding is advisable.
2. Inco Nickel Electric Welding Wire should be procured from the distributors of Inco products. This wire is flux coated under controlled conditions and is carefully tested for welding qualities. It is packed in five pound bundles in sizes from $\frac{3}{32}$ inch diameter to $\frac{1}{4}$ inch diameter by 18 inches long. Sound, ductile metallic arc welds cannot be obtained with bare or improperly fluxed nickel wire.
3. The operator should make trial welds with both straight and reversed polarity at several current values, and select the polarity and amperage that best suits the nature of the work and his own manipulative methods. Good welds can usually be made either with straight polarity or with reversed polarity, and the several inter-related factors make it difficult to devise a rule to cover all conditions.
4. The short arc—$\frac{1}{16}$ inch to $\frac{1}{8}$ inch long—is an absolute necessity. The efficiency of the flux in protecting the molten metal in its transfer through a long arc stream is seriously lowered.
5. The selection of the size of electrode and the adjustment of the welding current must properly balance the penetration and rate of electrode fusion.

Plate Thickness	Weld Rod Diameter	Amperage
$\frac{1}{16}$-$\frac{1}{4}$"	$\frac{1}{8}$"	90-150
$\frac{5}{16}$-$\frac{3}{8}$"	$\frac{5}{32}$"	140-160
$\frac{3}{8}$-$\frac{1}{2}$"	$\frac{5}{32}$"	160-190
$\frac{1}{2}$ and heavier	$\frac{3}{16}$"	180-225

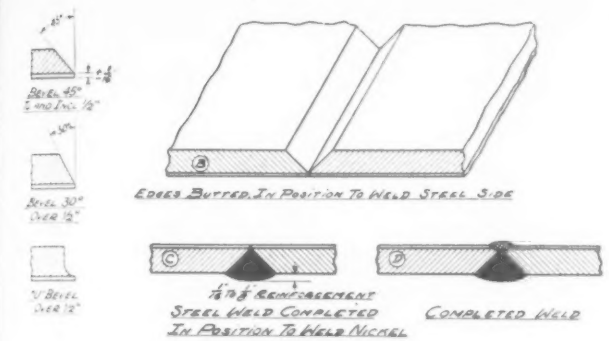


Fig. 2. Butt Welded Joint, Metallic Arc Welded.

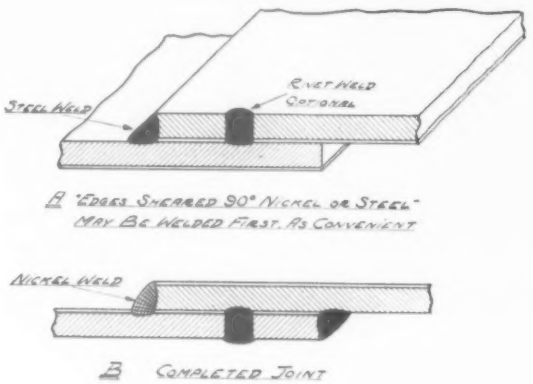

Steel Weld
Rivet Weld Optional
A "Edges Sheared 90° Nickel or Steel" May Be Welded First, As Convenient
Nickel Weld
B Completed Joint

Fig. 3. Lap Welded Joint, Metallic Arc Welded.

Types of Joints

The bevelled butt joint, Fig. 2, should be used whenever the nature of the work allows this type of joint. Field erections of large storage tanks may require the lap joint shown in Fig. 3. The various joints, Plate I, Figs. 15 to 18, are used to meet the particular needs of the construction.

Carbon Arc Welding

This is a highly desirable method of welding and can be relied upon to yield strong, dense welds of high ductility. Excellent results have been obtained in welding vertical joints because of the closer control over the rate of fusion and the placement of the deposited metal.

Inco Nickel Electric Welding Wire $\frac{3}{32}$" or $\frac{1}{8}$" diameter is used with carbon rods $\frac{1}{4}$" or $\frac{5}{16}$" diameter. The carbons are ground on an emery wheel to a fine point, tapering back one inch to two inches. They have low current carrying capacity and the larger welding amperages cause them to reach a white heat. A short grip, 3 to 4 inches long, is taken in the holder to prevent excessive wasting away from oxidation of the carbon and to improve the comfort of the operator. See Fig. 4.

Straight polarity, i.e. carbon negative, is used and if

the operator does not know the direction of current flow, the behavior of the carbon will provide a means to determine the proper circuit connection. Reversed polarity will cause the carbon to become blunt and to burn away rapidly. The crater, characteristic of the positive side of the arc, is usually present. The arc becomes "wild" and difficult to control. On the other hand, a properly connected circuit gives a smooth, quiet arc. The carbon retains the pointed end and operates at a much lower temperature.

The current is adjusted to as small a value as possible to give a steady arc and the proper rate of fusion. The weld rod must not be fed into the arc before the plate is heated sufficiently to melt the surface of the joint, and care must be exercised to keep a wetted surface ahead of the advancing pool of weld metal. Excessive amperage must be avoided to prevent the formation of troublesome cracks in the weld or on the plate at the point where the arc is broken.

Carbon arc welding will often prove useful in welding light gauge linings in outlet fittings, manholes, and other sheet metal in conjunction with plate work, and data on suitable current values are included in the following table for this purpose.

Plate Thickness	Carbon Diameter	Amperage	Filler Rod Diameter
.062-.125	1/4"	50- 80	3/32"
.125-.187	1/4"	80-100	3/32-1/8"
3/16-1/4	5/16"	90-120	3/32-1/8"
1/4-3/8	5/16"	100-125	1/8"
3/8-1/2	3/8"	110-150	1/8"

Acetylene Welding

The beveled butt joint shown in Fig. 2 is the best type for general use, but other types common to steel plate welding can be expected to give equally good results with the possible exception of the outside corner weld, Fig. 18A, Plate I due to excessive iron contamination. An analysis of the weld metal should be made to determine the suitability of this joint for the intended service.

The steel weld is usually made first, then the nickel weld as described under "Metallic Arc Welding." No change is made in welding the steel side over the accustomed practice in welding solid steel plate. The welding of the nickel requires observance of an all important rule—"Maintain a slightly reducing flame." The sharp flame that yields entirely satisfactory welds in steel will give brittle and spongy welds in nickel. The reason is the high melting point of nickel oxide and the absence of the free fluxing action of the molten oxide obtained in welding steel.

Inco Nickel Gas Welding Wire is used. This wire is supplied in 36" lengths and is used bare. Flux is not required but some operators may prefer to use a flux. Inco Gas Welding and Brazing Flux should, in this case,

Nickel-Clad Steel Filter Tank with Perforated Fake Bottom. Made by Atomic Hydrogen and Metallic Arc Welding by Liberty Coppersmithing Co., Philadelphia, Pa.

be used sparingly, but the flux must not be relied upon to correct a careless adjustment of the welding flame.

The reducing flame with a given tip size and acetylene pressure is not as intense as the sharp flame and a tip one size larger than the tip used under steel welding conditions may be required. With the larger tip, both the acetylene and the oxygen pressures should be reduced to give a soft easy flame.

Atomic Hydrogen Welding

The atomic hydrogen method is adaptable to the welding of nickel-clad steel plate, both on the steel side and

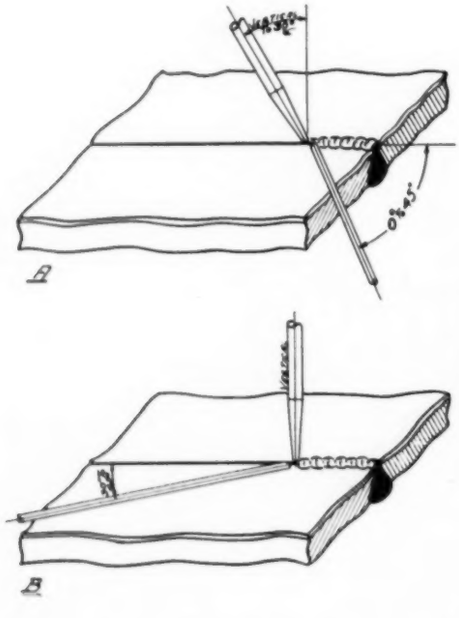


Fig. 4. Carbon Arc Welding. Operator to Select (A) or (B) According to Preference.

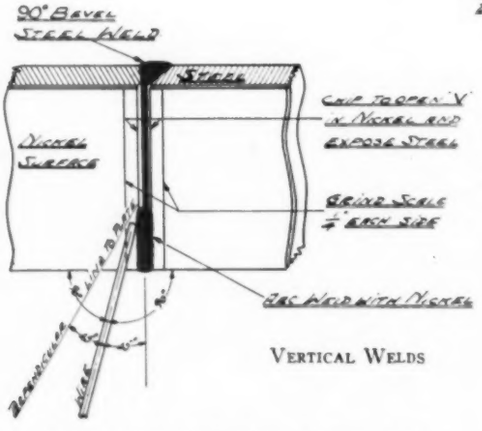


Fig. 5. Vertical Welding—Metallic Arc.

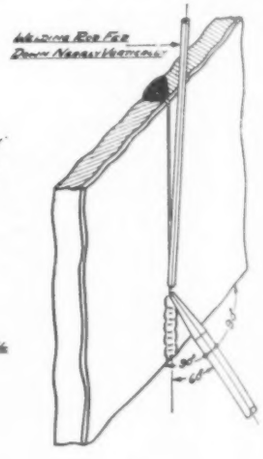
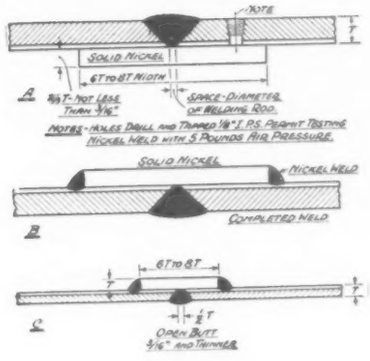
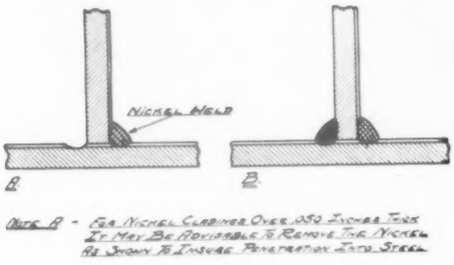


Fig. 6. Vertical Welding —Carbon Arc.


NOTE
SOLID NICKEL
6T TO 8T WIDTH
SPACE-DIAMETER OF WELDING ROD.
NOT LESS THAN 1/16"
NOTES-HOLES DRILL AND TAPPED 1/8" I. P.S. FOR AIR TESTING NICKEL WELD WITH 5 POUNDS AIR PRESSURE.
SOLID NICKEL
NICKEL WELD
COMPLETED WELD
6T TO 8T
OPEN BUTT 1/16" AND THINNER

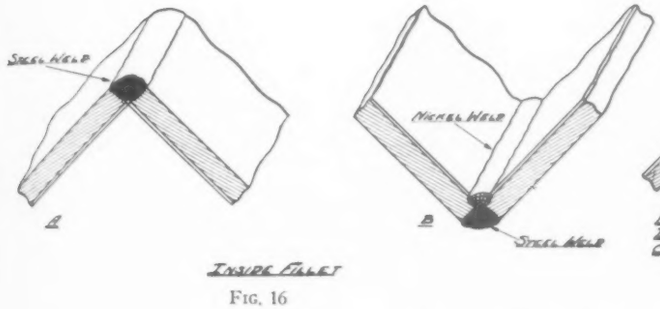
STRAP JOINT

FIG. 15


NICKEL WELD
NOTE A - FOR NICKEL CLADDING OVER .250 INCHES THICK IT MAY BE ADVISABLE TO REMOVE THE NICKEL AS SHOWN TO INSURE PENETRATION INTO STEEL.

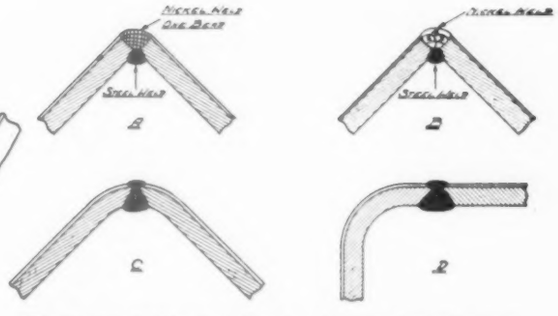
DOUBLE FILLET

FIG. 17



INSIDE FILLET

FIG. 16


NICKEL WELD ONE BEAD
STEEL WELD
NICKEL WELD
STEEL WELD
A - NOT PERMISSIBLE ON ACCOUNT OF LARGE IRON CONTENT OF NICKEL WELD METAL.
B - MULTIPLE BEADS WELL SPACED LOW IRON ELECTRODES WELD.
C & D - PREFERABLE METHODS.

OUT SIDE CORNER WELD

FIG. 18

Plate I. Types of Joints Frequently Used.

on the nickel side, without change in any respect over the welding of an equivalent joint in common steel. The welds are of excellent quality and, except for the possible higher welding costs over other methods, its use is highly desirable.

The preparation and assembly of the joints and procedure in welding follow closely the descriptions given under the electric and gas welding methods. The welding wire may be the bare Inco gas welding rod or the Inco flux coated electric welding wire. It is the writer's opinion, from observation of several tests, that the flux coated wire gives slightly better welds than are obtained with bare wire.

A small welding rod $\frac{1}{16}$" dia. or $\frac{3}{32}$" dia. is desirable except for plate over $\frac{1}{2}$" thick, or for heavy fillet welds when the larger $\frac{1}{8}$" dia. or $\frac{5}{32}$" dia. rod can be used.

Vertical Welding

In the erection of large storage tanks in the field, the tank cannot be kept in a position to weld all joints "down hand" as is possible in shop assembly. The operator must therefore prepare himself for vertical, horizontal, and, in rare instances, overhead welding. Vertical welding on the nickel side is readily accomplished and welds equally as good as "down hand" welds are obtained. This type of work is done usually by companies well organized in handling the many details of outside erections, and their welders are skilled in this class of work. The welding of nickel may be new to them, but by practice the average good welder will soon learn the manipulation that yields proper welds.

Metallic Arc

A greater degree of skill is required in vertical welding with the metallic arc than with the carbon arc, oxy-acetylene, or the atomic hydrogen methods. The deposition of the metal is affected by the adhesion and surface tension between the globule of molten metal on the end of the electrode, and the film of molten metal on the surface of the plate.

Vertical welding is started with a deposit at the bottom to form an almost horizontal face or shelf. The electrode is inclined as shown in Fig. 5, and fusion at the base of the weld is kept slightly ahead of the outside. The size of electrode, current setting, and polarity must be determined by careful trial. Generally, an electrode one size smaller than would normally be used for "down hand" welding and straight polarity will give the best results.

Horizontal welding with the metallic arc is accomplished by applying the same principles as in vertical welding. The shelf is inclined at an angle of about 45° from the vertical and the fusion of the lower portion is kept in advance of the upper portion. The position of the electrode is downward and to the side in a back-hand direction to the advancing weld.

Carbon Arc

Fig. 6 illustrates the position of the carbon pencil and the electrode in vertical welding. Carbon pencils $\frac{1}{4}$ inch diameter with flux coated electrodes $\frac{3}{32}$ inch diameter are used on plates to $\frac{5}{16}$ inches thick, and $\frac{5}{16}$ inch carbons with $\frac{1}{8}$ inch electrodes for heavier plate. The current is adjusted by trial to suit the plate thickness and effect prompt fusion of the base metal, but not so high that deep craters form on breaking the arc. The end of the weld rod is admitted into the arc stream just after the glossy film of molten metal shows on the plate and the face of the weld. The small diameter weld rod melts promptly and the metal is deposited smoothly and evenly.

Acetylene and Atomic Hydrogen

The welding of vertical and horizontal joints with the acetylene or the atomic hydrogen torch is almost as simple as "down hand" welding. The selection of the tip size, gas pressures, and weld rod in acetylene welding follows closely those given for "down hand" welding with the exception that a smaller weld rod should be used.

Atomic hydrogen will present the same conditions that apply in oxy-acetylene welding. The most intense portion of the fan is directed into the root of the weld, and the filler rod added in the same manner as in gas welding.

Iron in Nickel Welds

The weld metal on the nickel side of a properly fused joint is not pure nickel but is a nickel-iron alloy containing, in normal welds, not only 15% of iron. The molten nickel takes iron readily into solution in all welds where penetration into the steel is had. This effect is readily seen in Figs. 2 and 3.

The presence of iron must be expected and, if kept within bounds by proper design and manipulation, the resultant nickel-iron alloy will have good corrosion resistance.

The expected iron contamination in welds is as follows:

Fig. 2 Butt welds ..... 4 to 8%
Fig. 3 Lap welds ..... 7 to 15%
Fig. 16 Fillet welds—nickel inside ..... 3 to 7%
Fig. 18 B, C, D Corner welds—nickel outside 15% max.

Analyses of acetylene butt welds show a maximum of 15% iron. No records are available on other types of gas welds or on any of the atomic hydrogen welds. Inspection, however, of cross-sections of specimen welds indicates the iron content to be within safe limits.

The outside corner weld, Fig. 18 A, Plate I has been found to contain an excessive amount of iron—up to 45%—and this type is not to be recommended. Most constructions permit forming the corner to a radius as shown in Fig. 18 C, or flanging one side and butting the other

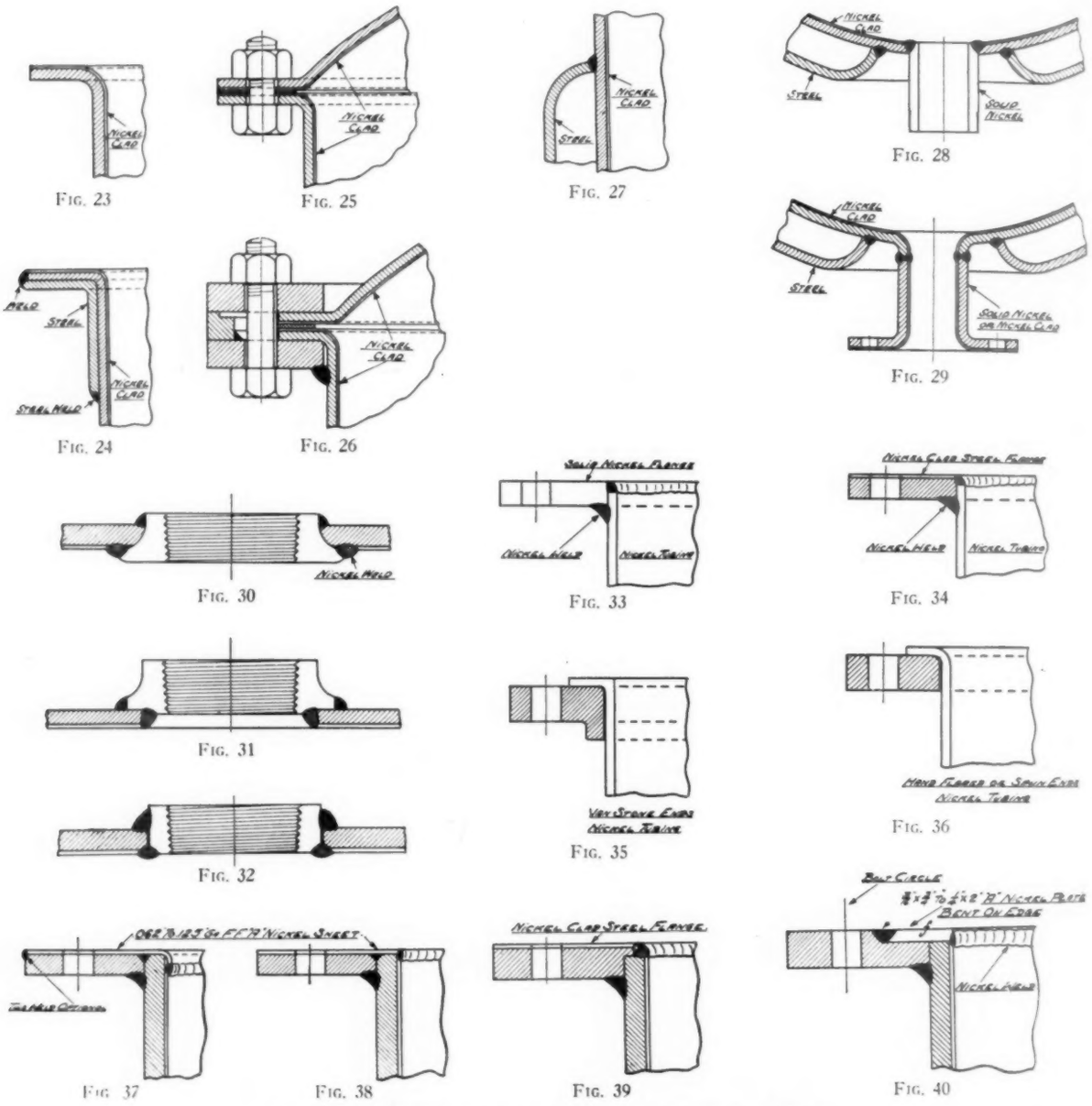


Fig. 23 Fig. 25 Fig. 27 Fig. 28
Fig. 24 Fig. 26 Fig. 29
Fig. 30 Fig. 33 Fig. 34
Fig. 31 Fig. 35 Fig. 36
Fig. 32
Fig. 37 Fig. 38 Fig. 39 Fig. 40

Plate II. Designs of Joints to Maintain Continuous Nickel Surface.

as in Fig. 18 D. If either of these two are impractical, the multiple layer weld, all beads of nickel, should be used in preference to Fig. 18 A. By progressively diluting the iron in the successive beads, the amount in the corner weld is easily reduced to a maximum of 15%.

Peening Welds

Peening or bobbing to compact the nickel weld metal is a highly desirable operation. The weld is improved in density, physical strength, corrosion resistance, and appearance. Pneumatic chipping hammers are used with flat faced tools slightly rounded at all corners. The tool is held squarely against the weld and moved back and forth laterally and across the weld with a rocking motion to conform to the curvature of the weld. Sharp cornered tools that may cut into the nickel along the line of the weld must be avoided.

Design

The maintenance of a continuous nickel surface is the only problem new to the design of pressure vessels and other types of equipment. The accompanying drawings, Figs. 23 to 36, Plate II, show methods of construction to provide continuity of the nickel surface at top reinforcing curbs, flanges, outlets, and fittings.

Figs. 23 and 24 show top reinforcing curbs for open vessels in the lighter plate gauges. The reinforcement of tanks in gauges too thick to flange is accomplished by welding steel angles, as in steel work. Pure nickel sheet may be applied over the top flange of the angle and welded to the nickel-clad plate, if desired.

Figs. 25 and 26 may be used for flared and dished cover plates on vessels that operate under pressure or vacuum.

Jackets are readily welded to nickel-clad vessels as in Figs. 27, 28 and 29. Any type of bottom outlet, either in solid nickel or nickel-clad steel, may be attached.

Forged tapped welding flanges in solid nickel to 4″ I.P.S. are available and may be applied either as shown in Fig. 30 or 31, with preference given to Fig. 30. Small tappings, about 2″ I.P.S. and under, may be machined from solid nickel bars and welded as in Fig. 32.

Built-up flanged fittings shown in Figs. 33 and 34, or loose flanges shown in Figs. 35 and 36, are suitable for outlets to 6″ I.P.S. Figs. 37, 38, 39 show suitable designs for large outlets, handhole, and manholes. Fig. 40 may be used for large flanges and is a particularly good design for bolted joints in evaporator shells, or similar large vessels, when machining facilities are available for facing the flanges.

General Ideals On Electric Welding Steel Structures

(Seventh and last in a series on "The Ideal Application")

By Paul B. Covey†

WE ARE now ready for some general observations on the future of structural welding.

First, regarding the consulting engineer in charge the greatest success will come to that man who definitely "forgets" bolts and rivets and thinks only in terms of welding. It is not that there is no more use for bolts and rivets—as some seem to indicate—that would be a foolish idea, but a man is seriously handicapped unless he tackles welding with a mind entirely free of all riveting prejudices. This should apply not only to the engineer in charge, but also to all those connected with the welding program. The concern that has set apart an entire group of men who specialize exclusively in welding and forgets all else but welding details and welding construction will progress much more rapidly than one which tries to mix the two methods of fabrication.

There should be in the architect's office a welding engineer in charge of all steel work—whose duties are to prepare and supervise all details of the structural steel and ornamental iron necessary for each set of plans leaving the office. He should be primed to the minute on the latest welding developments—and thoroughly familiar with the most approved systems of welded details and with the latest and most satisfactory methods of testing finished welds. In fact, he should be in every way an expert on welding as applied to structural steel and ornamental iron.

Likewise the steel contractor should be thoroughly familiar with welding costs, methods of welded fabrication and erection, and all the little tricks necessary to make every saving possible through the use of this most economical process.

Then again, in the shop of this same steel contractor there should be a welding engineer looking after all shop welding details, hiring and training all welders, supervising all welding operations, inspecting all finished welds—in short, in full charge of all parts of the welding program.

On the job itself all field welding operations should be in full charge of a thoroughly trained and competent welding engineer.

Why *shouldn't* all this work be correlated under one head? Why shouldn't there be employed by the owner direct, or by the architect for the owner, one welding engineering concern which would take full charge of the welding program clear from its infancy—its inception in the office of the architect—on down through its development in the shop to its completion in the field—one group of welding experts, which could correlate activities *all* the way down the line, saving duplication of effort, chances of misunderstanding, possibilities of errors and resulting in a unity of thought and action as could not be accomplished in any other manner?

Some day there will be in effect *just* such a correlation of effort, not only in the welding but in all branches of the construction. The public which has been a doubting public is becoming "welding minded." It is accepting with confidence welded designs and welded details. Cities are permitting welded construction for all field work on new office buildings—doctors and nurses are demanding welded construction for all field work on new hospitals and asylums—teachers are demanding welded construction for all field work on new schools and colleges.

We shall see steel mills in the future turning out many new and radically different shapes designed especially for welded construction, and welded details very greatly simplified and thoroughly standardized and complete handbooks of such standards in common use in all steel construction offices.

†*Consulting Welding Engineer, Manchester, N. H.*

In order to increase the production rate of welding machines without loss of quality one must study all of the variables which affect the job. Here is an outline of control methods which take care of the principal difficulties encountered.

Problems in Machine Welding*

By J. L. Anderson†

FUSION welding practiced mainly as a manual operation, and therefore not generally recognized as a mass production process in the accepted meaning of the term, has led many to attempt the mechanizing of this operation in the production of a great variety of sheet and plate metal articles of commerce.

Unlike machine tool operations or chemical processes that utilize materials and methods which have become standardized through long experience, the application of welding by mechanical means applied to many types of products necessitates considerable trail blazing before real success can be achieved. Too often efforts are made in this direction considering only the mechanical set-up, or the mechanical motions required, disregarding the variables that must be reckoned with not only in the materials employed, but those also which are developed or are encountered oftentimes as a result of or inherent in the material or in the welding process itself.

Advantages of Manual Welding

In the usual hand welding operation a grade or quality of materials may be employed, which, while not offering the ideal condition for satisfactory welding, still permit the experienced welder through the exercise of more intelligence than he is usually given credit for, to produce in a way that appears to satisfy.

The problems which may be encountered are the variation from standard of the material which he is welding, or of the adding material, or it may be the condition of the equipment, either directly or indirectly employed in the welding operation, or it may be the previous preparatory operations inaccurately performed. Notwithstanding all this, by the exercise of intelligence, good judgment, skill and patience the welder is able to produce in an acceptable manner.

Mechanical operation of the welding torch under similar conditions would scarcely result in success unless provision is made in several portions of the apparatus to compensate for these conditions, or unless the welding method is susceptible of modification more or less independently of manual control.

The Material Problem

In the matter of material, for instance, it may be that under fusion it foams, or perhaps it is sluggish, and does not flow freely, it may be too fluid, or it may erupt in spots as it congeals, leaving cavities or unbroken bubbles. Whatever the difficulty is, it is obvious that a welding machine of itself cannot overcome these difficulties, automatically, although they may be subject to correction under proper conditions through changes in procedure or adjustments in the mechanical set-up.

The same holds good to a very considerable extent if the trouble is one of variation from standard in the adding material. Much can be accomplished in the matter of securing quality material of the right kind by close cooperation with the supplier.

Cooperation With Material Supplier

Steel companies supplying large requirements to specification or otherwise, will invariably endeavor to correct or modify mill procedure, or will select and process material of known characteristics in order that specific results may be attained in welding, obviously it is more logical and more economical to apply corrective methods at the source through cooperation, even at an increased cost per ton, than it is to vary welding procedure, or technique, at probably a continuous expense, or to modify equipment, or sacrifice efficiency in the manufacturer's plant in order to secure perfection in weld metal quality. In other words, if the steel mill can, with metallurgists and other informed men, modify mill procedure, or supply material of satisfactory composition, it is foolish for the manufacturer to attempt to make similar corrections in the weld puddle with less qualified employees.

Frequently it is found that there is gas entrapped in the weld as the metal solidifies which tends to erupt in closely grouped relation, leaving cavities which do not, as a rule, penetrate the entire thickness of the seam, but which are frequently referred to as pinholes, gas pockets, etc., and are invariably charged against the welding process. Experience has taught that the difficulty is generally encountered when inadequate or when improperly drawn specifications are submitted, and while material which behaves this way does not seriously affect steel quality, it does interfere with weld quality.

Effect of Gas in Steel

When gassy steel is encountered it is far more troublesome in mechanical welding operations and may not even be noticed in hand welding, due to the great difference in the welding speed. The hand welder by reason of his slower rate of progress keeps a mass of metal fluid for a longer period; obviously then, the problem is a similar one for the mechanical welding engineer, but it is not quite so simple as all that, for due to the higher welding speed

*From a paper presented before the American Welding Society, New York, April, 1932.

†Research Engineer, Air Reduction Sales Co., New York, N. Y.

and the greater concentration of heat, he cannot permit the same time for fluidity to exist, due to the possibility of overmelting, but he can, under proper conditions, prolong the melting time by progressive melting and accomplish the same or the equivalent result.

Costly errors are often made by assuming that material which has satisfactorily withstood the test of experience in some other method of production, is equally suitable for machine welding. As a matter of fact, **the requirements for production by machine welding methods are exacting, if high weld quality and close manufacturing tolerances are demanded.** In this connection it may be well to remark that **correct chemical analysis is not an assurance that weld quality will be satisfactory** and the cooperation of the mill is therefore important in securing material which not only meets the chemical and physical specifications, but also behaves satisfactorily when it is remelted in the welding operation.

Mechanical Principles Control Design

In the matter of machine and apparatus design and maintenance, we have something that is purely mechanical and a careful analysis of results will clearly indicate to what extent the results are directly traceable to correctness of design of both machine and welding apparatus. The same is true of the results as they may be affected by machine or apparatus condition.

There are several important factors which should be considered in machine design, as they may affect the result, considering now only the facilities for holding the material to be welded, and the welding operation also as it is affected by various other factors.

Heat Effects

Let us consider for the moment the heat effect. Heat is the basis of all welding operations and the absorption of heat brings about conditions which the welding machine or the operator must counteract in order that acceptable welds may be produced at all times.

In machine welding operations the absorption of heat, whether extremely localized or more generally distributed, sets up movement of the metal which manifests itself in various ways and the amount of movement or distortion with which the designer or operator must contend influences not only the design of the machine, but very frequently the method of heat application and dictates the necessary welding procedure, as well as mechanical and other adjustments.

Dimensions of Stock

The thickness of the metal to be welded and the form in which it is presented to the welding means, also govern to some extent the type of distortion which occurs. In speaking of distortion, it is not my purpose to convey the idea that the entire part is caused to warp out of shape, but rather to call attention to an extremely localized condition which occurs immediately at the welding point and which disappears almost entirely when the heat application is removed and the metal returns to normal temperature.

As an illustration we will consider first the straight butt seam weld in which there are two principal reactions with which we must contend. One is due to the rate of heat transmission which causes the metal to curl downward through surface expansion because the surface absorbs heat faster than it is transmitted throughout the thickness of the metal, and because of flexibility and greater proportion of surface to thickness, the thinner sections are most seriously affected in this respect.

Distortion From Restrained Expansion

The other is the distortion which is the result of restrained expansion. This is manifested by a bowing upward or downward of a portion of the edge sometimes independent of the first-mentioned result, but frequently in combination.

As a matter of fact, this distortion, usually in both forms, is always present to a greater or less degree in all welding operations, depending upon the type of material and thickness, particularly when the unsupported edges are unduly exposed beyond the control portions of clamping or holding devices employed in positioning the seam edges.

It is frequently noticed that one edge of the seam will assume the raised, bowed form, while the other edge will at the same relative point take the downward curved form, or both may assume the same form, or even alternate from time to time, depending on what forces are at work in various points. This condition of distortion is more or less continuous from the beginning to the end of the seam and progresses with the welding operation. In fact, it is part and parcel of the welding operation, and compels recognition on the part of the designer of the machine, in order that the welding machine will function as effectively as it should and the welding operation be successfully performed. It is a condition of which the welding machine operator will be conscious if he is determined to produce the finest possible weld, and he will, insofar as it is possible, personally make adjustments to minimize the condition, or stipulate, if he is able, the changes in design or procedure to accomplish the desired results.

Remedial Measures

This remedy lies in one of several modifications. More concentrated heating, or more generally spread heat, depending on the means of seam control, or more positive seam control if speed is not to be sacrificed. Much can be done to minimize the results of this tendency of metal to move more or less erratically under the influence of concentrated heat by means which will restrain its erratic movement by providing means for controlled movement and oftentimes forcing this movement to assist in the performance of the welding operation, or at least utilizing and controlling the forces to improve the weld strength and often the weld quality.

Nothing has been said of the general lateral and linear expansion as this is not usually troublesome and is overshadowed to a considerable extent by the two more pronounced forms just mentioned.

Considering these remarks as applied to material which has been formed to some predetermined shape, we will find that the same forces are at work but that a totally different result is produced.

Tube Welding

Let us first look at the welding of an open seam tube by the gas welding process.

We find that the first noticeable effect of the heat is the release of the strains introduced in the forming of the tube, and its edges tend to separate due to the heat effect on both internal and external surfaces followed by a straightening out of the curve of the upper quarter as the rolling strains are further released, which not only

causes the seam edges to open further, but causes them to present a perceptible angle to each other in the edge faces which were originally practically parallel.

Further heat absorption then causes the edges to assume a partially bowed form, longitudinally restrained to a considerable extent by the shape and form of the tube and more particularly by the controlling members of the welding machine, while in addition the entire tube within controlled or uncontrolled limits assumes a decidedly bowed form due to the effects previously mentioned, plus the more general but graduated heating of the entire circumference of the tube, but particularly the upper quarters of the tube.

As the tube travels and the welding operation progresses, this condition of distortion reaches a maximum, and adjustments provided in the machine design for the control and utilization of such effects are made in action or otherwise, which counteract and at the same time utilize the result to produce better welds more economically than would have been possible otherwise. By this I mean, that having adjusted for this progressive distortion and to a considerable extent assumed control, it is possible by the disposition of the heat application and its intensity to utilize the conditions set up by distortion to secure through penetration greater welding speed and more mechanical working of the metal.

Why Correct Forming Is Best Control

Immediately the thought occurs why not deliberately set up conditions that would produce these results rather than attempt to counteract and utilize them advantageously. The answer is, that regardless of the steps taken to duplicate in the cold state conditions which occur, under heat the same conditions recur in either modified or exaggerated form which frequently makes it more difficult to secure desired results. It is more desirable to attempt control by deliberately reducing the resultant distortion by reason of working out a forming procedure that takes into account known results of specific types of heat application.

While the hidden variables and the distortion which is incident to the welding operation may not be particularly troublesome, the result of this combination of conditions which is very apparent at the completion of the operation may have affected the operation during its progress through the strains set up which the machine design must be able to counteract in order that the otherwise controlled conditions are not upset.

These are the longitudinal and transverse contraction stresses which follow the weld and reach their maximum effect on the welding operation when the welded portion has cooled to the lowest degree while it is still within the control or confines of the machine. These two stresses may be of unequal value and therefore the effects of the more powerful will become evident while the other, although undetected, may be exerting an appreciable effect upon the results.

Unequal Heat Absorption in Circumferential Seams

The straight butt seam is usually the operation which brings to the attention of the experimenter or the operator the forces that are released or the problems that must be surmounted in order to satisfactorily weld a seam; but the solution of problems involved in straight seam welding are only moderately helpful in successfully applying mechanical welding to a circumferential seam.

While the same forces must be reckoned with, they frequently are not so pronounced, but there is the additional condition of unequal heat absorption or conduction which, if it is allowed to persist, gets entirely out of control by progressively creating an effect of unequal diameter in that one edge will endeavor to rise above the other and when the starting point is reached a very decided buckle is left to indicate that something went wrong. When this occurs, it is frequently found that the transverse contraction stress has also played a part and prevented mechanical control by taking advantage of the opportunity to slip under the elevated edge, thereby aggravating the trouble.

Let us now consider a more complicated operation and one which is perhaps more frequently attempted and offers more discouragement than any other type of machine weld ordinarily attempted.

Typical Problems Encountered

Reference is made to the circumferential weld between two deep drawn, stamped or rolled sections with straight sides, or a stamped section joined to a rolled section with straight sides or dissimilar sections with similar meeting edges. This type of operation offers difficulty by reason of the problems of holding and controlling edge position while at the same time permitting free or controlled expansion as may be necessary by reason of the form of the parts to be joined. Consider, for instance, a circumferential butt weld in a plain, fairly light sheet steel, one which must be finished to leave no trace of the weld. Circumferential expansion of the entire part must be considered, and uniformity in both meeting edge positions maintained, while in addition there occurs the extremely localized expansion which results in a bulged condition and which must be maintained uniformly in both meeting edges in order that complete and equal fusion may be produced between the opposing edges. We are compelled also to recognize the longitudinal expansion which tends to force the edges away from each other and may even present the unwelded opposing edges from meeting, thereby interfering with the satisfactory completion of the operation.

In this type of operation it is generally expedient to provide for modification of the heat application during the progress of the weld to counteract and control unequal expansion and uneven heating through variation in the conductivity of heat away from the welding point and thereby secure approximately uniform conditions throughout the complete operation. Every welding operation of the circumferential type is often an individual problem because of variables of different kinds and in varying degrees are encountered in similar parts. Manufacturers who by reason of their type of products utilize mechanical welding on formed parts can very considerably reduce welding costs by instituting an inspection operation when quantity warrants which will permit segregation of parts likely to be influenced by measurable variables and run such lots through the welding machine under conditions of control which will insure greater success and lower over-all cost than if welded just as they happen to be selected by the operator.

Control of Major Difficulties

Without going into detailed explanation of control and corrective methods for each individual condition, I believe

(*Continued on page* 39)

Modernizing for Profit

Figure 1. The 3-Inch A. A. Mobile Gun in Firing Position.

Ordnance Making Revolutionized*

By Major G. M. Barnes†

MODERN welding had never been used in the construction of gun carriages by the Ordnance Department, United States Army, until the work described here was undertaken at the Watertown Arsenal. In fact there was a strict ruling against the use of any welding whatsoever in connection with gun and gun carriage work. It was considered that welding was not only an unsatisfactory method of construction, but dangerous, as practically all parts of the carriages were called upon to resist large impact forces.

It would be difficult for one not familiar with Ordnance practice, to appreciate the dependability which must be built into a piece of Ordnance. The requirements for strength and long life are usually far beyond those which would be considered satisfactory for commercial machines. The reasons for this are readily understood when it is considered that Ordnance in war must function under the most adverse conditions in the field where repairs are exceedingly difficult, if not impossible, to make. A single mal-function due to a weak or defective part may result in the death of several men. If a piece of artillery goes out of action for a few minutes, due to a mechanical fault, its whole value may be lost. This would not condemn most commercial machines which could be repaired and put to work.

The 3" Antiaircraft Mount (Mobile) shown in Figure 1 was selected as the best carriage to test the possibilities of welding gun carriages, for the following principal reasons:

It represented the most modern type of post-war gun carriage, which had been standardized by the United States Army. This carriage was under production at Watertown Arsenal. It was of the mobile type, i. e., on wheels, and its members were subject to severe road shocks in addition to the impact forces due to firing. The principal parts of this carriage were highly stressed and of intricate design. The 3" A. A. Mount which was originally made almost entirely of cast steel, had passed all tests, had been standardized, manufactured and issued to the service prior to the substitution of welded parts. It was felt that if a success could be made of welded parts for this carriage there would be little question concerning the successful application of welding to other types of artillery.

The 3" Gun Carriage is shown in the traveling position in figure 2. It is folded so as to form as compact a traveling load as possible. The unit is trailed over roads and across country behind a suitable prime mover. Although weighing 8 tons, the carriage can successfully travel at speeds up to 40 miles per hour, without damage to the various mechanisms.

Figure 1 shows the unit in the firing position. The front and rear two wheel bogies have been removed and the mount lowered to the ground by means of screw jacks built into the carriage. The long arms, called outriggers, in this position have been opened and stand at 90° to each other when flat upon the ground. The mount is so designed that although it is not anchored to the earth in any way, it will not move or lose its orientation when the gun is fired rapidly.

The pedestal was also made of cast steel. The four main outriggers are secured to the pedestal by means of heavy pins, which permit these outriggers to swing in a horizontal plane. They can thus be folded together to

*This is a brief of a paper by Major Barnes which was awarded second prize in the Second Lincoln Arc Welding Prize Competition sponsored by The Lincoln Electric Company. Major Barnes was awarded $3,500 for his paper and in its original form it consists of approximately 100 pages of typewritten description, data and photographs. The complete paper with other prize winning papers will be published in book form by the sponsors of the competition.

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form the trailer body. Each outrigger is in three sections, which are folded when traveling. The main outriggers, at first, were made of cast steel, then of cast steel ends to which "I" beams were riveted. When traveling, the gun carriage is supported by 2 wheel bogies. Two half elliptic springs are mounted on each bogie axle. The springs, in turn, are secured to the bogie frames, which were also originally of cast steel. In addition to these main members there are also the elevating and traversing mechanisms which are used to give the gun the required elevation and angle of traverse or direction. In all, there are 1211 different parts used in the construction of this carriage, only the principal ones will be described.

The top carriage directly supports the gun with its recoil and recuperator mechanisms. It is called upon to

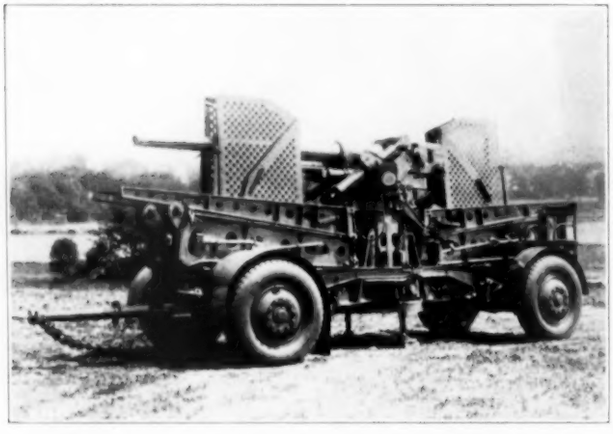


Figure 2. The Gun Ready for the Road. Note How Folded Outriggers Form the Trailer Body.

take the direct shock of the discharge of the gun and to transmit this load through the pedestal and outriggers to the ground. The gun swings through the two main arms of the top carriage, its elevation being controlled by the elevating mechanism secured to the top carriage.

This component was originally designed as a one-piece casting of ½" section with the lower stem integral.

Important steel castings, such as the top carriage, are thoroughly X-rayed at Watertown Arsenal before being accepted for use as gun carriage parts. Many of these castings when X-rayed were found to have shrinkage cracks, sometimes in the main arms and sometimes near the trunnion supports. The number of rejections became alarming.

In attempting the redesign of the top carriage it was of course necessary that the new part have the same general exterior contour as the cast steel top carriage, in order that no other adjacent members would require modification. It was decided to use a medium carbon steel plate ½" thick, which would produce a top carriage of about the same weight.

A number of these welded steel top carriages were then constructed, assembled to carriages under manufacture, and issued to the proving ground and using service for tests. All of these top carriages were found to be satisfactory and passed all tests. There were no failures.

These experiments convinced the writer that this member could be successfully made of ¼" nickel steel, thus securing an important saving in weight. Weight saving is of great importance in mobile gun carriages, as it is in the case of mobile commercial vehicles and machines.

An experimental top carriage of ¼" nickel steel was next designed and built. The construction followed that of the ½" welded top carriage except that light forged caps welded to supporting ribs were substituted for the separate forgings at the trunnion bearings and a stem of drawn seamless tubing was used.

When completed, the relative weights of the cast steel and the welded top carriage of ¼" nickel steel were as follows:

Cast Steel	975 lbs. (in rough)
Welded ¼" Nickel Steel	607 lbs. (in rough)
Saving in Weight	368 lbs. (or 37.7%

This welded top carriage is shown in Figure 3. The pedestal for this carriage was originally of cast steel of about ½" section. The physical requirements of the cast steel for this part were the same as for the top carriage. This was not as difficult a steel casting to make as the top carriage. Many of these castings, however, were found to be warped, especially the two pointer like projections at the base, which were often curled upward. This made it sometimes very difficult to lay out the casting and to shift the center lines so that it would clean out. The

Figure 3. Welded Top Carriages Made from ¼-Inch Nickel Steel.

pedestal was the next part of this carriage to be considered for welding after a success had been made of the welded top carriage. It was decided to go the limit at once in the design of this part, in making it of the lightest possible material consistent with strength and rigidity. For the sides of the pedestal, $\frac{5}{32}$" nickel steel plates were selected, while ¼" and ½" nickel steel plates were used for other parts.

The relative weights of the cast and welded pedestals shown in Figure 4 were found to be as follows:

Cast Steel Pedestal (finish machined)	1,115 lbs.
$\frac{5}{32}$" and ¼" Nickel Steel Pedestal (finished machined)	823 lbs.
Weight Saving	302 lbs. (or 27%)

The intermediate and outer outriggers are folded so as to lie above the main outrigger when traveling. When the carriage was first built the inner and intermediate members were made of cast steel of the same quality as

used for the top carriage and pedestal. The outer member was constructed of cast steel ends to which steel plate was riveted.

While the cast outriggers were found satisfactory, it was thought that at least the inner outrigger could be improved by using cast steel ends to which an I-beam section was riveted. This was tried but without any material saving in weight or cost.

The next move was to reduce the weight of these outriggers by using heat-treated, aluminum alloy castings, redesigning them to obtain the requisite strength and rigidity.

These outriggers have again been redesigned using ¼" and $\frac{5}{32}$" nickel steel plates and will soon be placed under

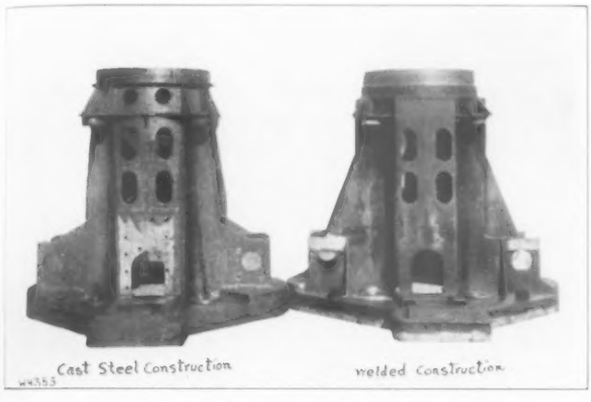


Figure 4. At the Left is Shown the Old Cast Steel Pedestal. The Welded Design Is Shown at the Right.

production. The requirements of keeping the weight within that of the aluminum alloy outriggers has been met to all practical purposes. This is possible, when it is considered that nickel steel has a proportional limit nearly four times greater than cast heat-treated aluminum alloy while the modulus of elasticity of steel is also three times that of aluminum. The weights of the cast steel, built up, aluminum and welded outriggers follows:

Member	Weight of Cast Steel Lbs.	Cast Steel Welded to I-Beam Lbs.	Weight of Aluminum (195 H4) Lbs.	Weight of Welded Nickel Steel Lbs.
Main outriggers	2,660	2,500	1,765	1,668
Intermediate outriggers	1,360	.....	680	800
Outer outriggers	720	.....	400	540
	4,740	2,500	2,845	3,008

While the aluminum outriggers have given satisfactory results in service, it is felt that the nickel steel outriggers, the first set of which has recently been completed and tested, are superior when it is considered that the elongation of aluminum alloy is but 6% as compared to 18% for nickel steel. In the event of an accident such as the overturning of the carriage which might produce stresses above the normal, an aluminum outrigger might snap, while the nickel steel beam of the same strength probably would bend and could be straightened and used again.

A study of the bogie frame indicated that it could be made an integral unit by using welded nickel steel plates, thus eliminating all the machining previously required to permit the five separate castings to be joined together. The weights of these frames are as follows:

	Front Bogie Frame Lbs.	Rear Bogie Frame Lbs.
Cast Steel	590	558
Welded Nickel Steel	430	380

This frame illustrates very nicely one of the advantageous characteristics of welding; that of making it possible to weld separate members into a unit, thus eliminating all intermediate machine work which was formerly necessary to permit the separate castings to be assembled.

Due to the success of welding guides on the gun, a new type of cradle made of welded steel plates has been designed for this carriage. This cradle, which is now under construction, is shown in Figure 5. One of the principal advantages of the welded cradle will be lightness. The relative weights of the two cradles are as follows:

	Lbs.
Cradle of cast steel, unfinished (actual weight)	588
Weight of welded nickel steel crade (computed)	330
Estimated saving in weight	258

Welding, as a result of this pioneering work which has been done at Watertown Arsenal, has become so well

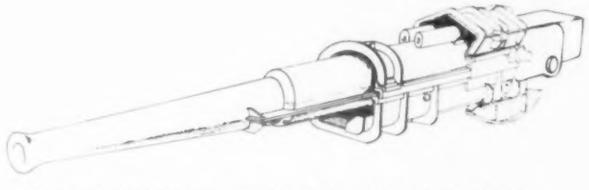


Figure 5. Welded Cradle for Gun with Welded Guides.

established as a process of manufacture, that several new types of Ordnance have been built recently, in which welding was adopted at the outset so that the parts were designed originally as welded members. When this is done the welded parts are invariably lighter, less complicated, more easily fabricated and considerably cheaper.

In considering this 3" A. A. Carriage, it must be borne in mind that this unit was originally designed as a structure to be built of cast steel members and that the welded members followed closely the design of the steel castings, which they replaced. It would be advantageous now to redesign this carriage from the ground up, on the basis of using welded steel members throughout. Such a replacing carriage would be very much simpler, would permit of more rapid production and hence would be very much cheaper.

In this work it has been found that designs can be made of welded members which would have been impossible if cast components had been employed. Our experience has shown that welding opens an entirely new field to the designer of Ordnance material, which will have a very far-reaching effect on the Ordnance of the future.

The solution of a difficult fabrication problem is found in a combination of (a) careful set-up, (b) correct current adjustment, (c) multiple-layer procedure, and (d) peening as soon as possible after metal is deposited.

Welding Chrome Vanadium Steel

By E. R. Corneil†

WHEN fabricating certain types of equipment from tubing the general practice has been to join the ends by using flanged fittings. This method of fabrication is expensive, requires considerable space for installation and must be carefully fitted to insure a tight joint, while a welded joint does not require exact machining to assure tightness, yet gives a better appearance and above all, it can be made at a lower cost. Even with these major advantages in favor of the welded joint, the element of doubt and the lack of information have deterred its adoption for high pressure work where alloy steels are used such as the chrome vanadium steel to which this article refers.

Fig. 1.

It was proposed to fabricate a piece of equipment using tubing having an inside diameter of 2¼" and a wall thickness of ½". This equipment was to operate at a pressure of 5,000 lbs. per square inch. A complete flanged joint in this tubing cost approximately $20.00, while a welded joint could be made for less than one-fifth of this amount, provided good ductile welds could be produced without making subsequent heat treatment of the whole equipment necessary. Should heat treatment after welding be necessary fabrication by welding was out of the question due to the size of the equipment.

In many such cases the heat treatment subsequent to welding is the greatest deterrent as this requires expensive equipment and especially so if the finished welded parts are bulky. Much equipment which should be welded therefore, is fabricated by other means, the heat treatment presenting such a formidable barrier that further thought is not given to the problem. Often a welding procedure might be used, however, which would result in joints as efficient as those receiving heat treatment and thus permit ready fabrication at a substantial saving.

In attacking the problem it is essential that the composition of the steel be known. Information of this nature furnished by the manufacturer generally can be relied upon. To eliminate errors, especially if the steel has been in stock, it is advisable to have an analysis made by a laboratory specializing in this type of work. Besides obtaining the analysis of the steel, it is well to know the physical characteristics and the heat treatment to which it has been subjected.

Referring to the steel tubing in question, an analysis made of a composite sample taken from various pieces was determined as follows: carbon 0.22%, manganese 0.73%, chromium 0.97%, vanadium 0.15%. The tubing according to the manufacturer's specification was soft annealed with a minimum yield point of 50,000 lbs. per square inch.

The analysis of the steel forms the basis for choosing the welding rod. It is in general good practice to use a filler rod which when deposited will have an analysis similar to the metal welded. In the majority of cases such a rod can now be found on the market. If a satisfactory rod cannot be obtained in this way, the manufacturer of steel can often furnish the rod or at least supply information as to where it may be purchased.

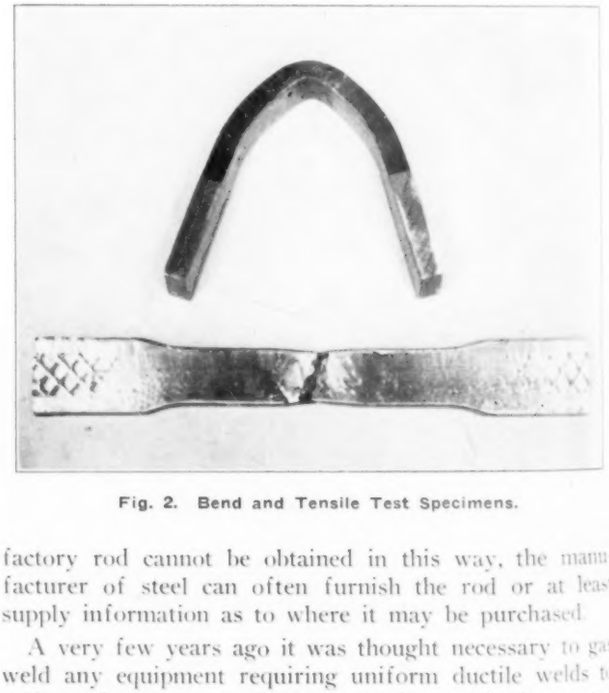


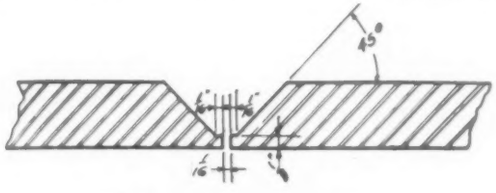
Fig. 2. Bend and Tensile Test Specimens.

A very few years ago it was thought necessary to gas weld any equipment requiring uniform ductile welds to withstand pressure. Since the advent of the coated electrode, the choice of a welding procedure is not so simple. The composition and the heat treatment of the steel, the shape and thickness of the parts to be welded, and the service expected are some of the points that must be considered, as only occasionally can similar results be obtained by either the metallic arc or the oxy-acetylene torch. In the case in question welds were made by both processes and specimens similar to Fig. 2 were cut from

†*Welding Consultant, Roessler and Hasslacher Chemical Co., Niagara Falls, N. Y.*

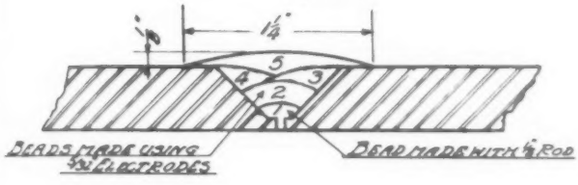
each piece and tested with results shown in the following table.

Sample	Yield Point	Tensile Strength	Elongation in 2"	Remarks
Unwelded	63500	85500	29.5%	Good ductility
Gas Welded	78500	85200	.....	Weld unbroken
Gas Welded	89500	89500	.....	Weld unbroken
Gas Welded	82400	84600	.....	Weld unbroken
Arc Welded	56500	68000	6.0%	Broke in weld
Arc Welded	58000	75000	11.0%	Broke in weld
Arc Welded	56000	68500	6.5%	Broke in weld



TYPICAL METHOD OF MACHINING TUBE ENDS

Fig. 3.



TYPICAL METHOD OF APPLYING BEADS

Fig. 4.

The yield point was taken as the stress producing a deformation of 0.01" in 2" under load. It was measured at the center of the bar or across the weld in each instance. As the yield point of the parent metal was somewhat higher than that deposited by the arc, the elongation shown for the arc welds is almost entirely that of the weld metal only. The elongation of the weld metal therefore, is likely to be 20%. The yield point of the metal deposited by gas welding is higher than that of the parent metal which was also increased as a result of the prolonged high temperature incident to torch welding. The bars broke in the parent metal more than an inch from the welds.

A further investigation of the gas welded bars showed them to be very brittle, bending less than five degrees. The brittleness extended some distance from the weld and heat treatment would be essential to restore the steel to its original properties. A comparison of the photomicrographs (Figs. 5, 6 and 7) shows that there has been a considerable grain growth in the parent metal adjacent to the weld made by the torch while no grain growth in the parent metal adjacent to the metal applied by the arc is to be noted. The arc welded bars could be bent without fracture as shown in Fig. 2 and it would appear that heat treatment is unnecessary.

The typical method of machining and setting up the tubing for arc welding is shown in Fig. 3. As the welding must be done on one side only and it was desirable to have a smooth joint on the inside with the assurance that the weld was completely through, the tubing was bevelled at 45° except the inner ⅛" which was left projecting 1/16". These projecting portions allowed sufficient width at the bottom of the groove to permit the ready manipulation of the electrode in applying the first bead. Care was taken that the sections of tubing were accurately lined up and the ends spaced 1/16" apart. The surfaces to be joined were cleaned thoroughly just previous to welding.

In the condition as deposited the weld is essentially a casting and therefore somewhat inferior to the rolled and forged parts which it joins. In addition to the coarse crystalline structure there may be high internal stresses even though they have been partially relieved in a ductile weld due to its plasticity. Peening or hammering the weld not only removes the slag but deforms the ductile metal in the direction required to relieve the shrinkage stresses. Peening should be done as soon as possible after the weld is made. Each layer of weld metal should be relatively shallow as compared with the total thickness of the joint as the heating of the previously hammered layer of weld metal by the next one laid on top of it causes the plastically deformed crystals to recrystallize and the original cast structure disappears from this part of the weld leaving it practically free from internal stresses.

With these facts in mind the beads were applied as shown in Fig. 4. The lowest current that would maintain a stable arc was used and closely regulated. The tubing was set up in a jig and rotated by hand at a speed equal to the rate of welding so that the location of the arc was almost constantly about 30° from the top center of the tubing in the direction of rotation. This procedure as-

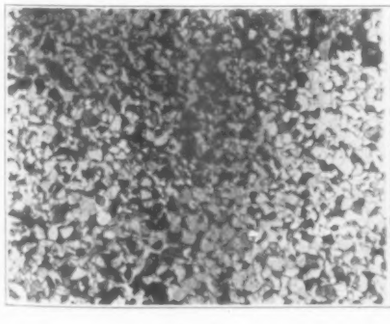


Fig. 5.

Gas weld using a one per-cent Chromium rod showing weld metal on the right and parent metal on the left. 300X. From a comparison of the parent metal shown in Fig. 5 with that shown in Fig. 7 the grain growth is evident. The parent metal in both cases was taken from the same piece of tubing and of equal magnification.

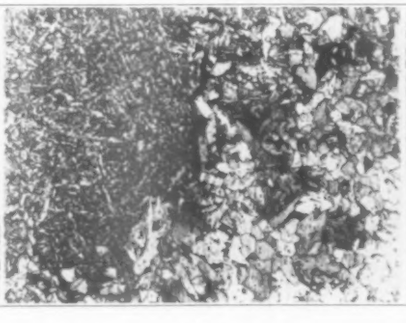


Fig. 6.

Section of arc weld taken near the surface of the outer bead, showing weld metal on right. 300X. From a comparison of the weld metal in Fig. 6 with that in Fig. 7, both sections in the same weld, the refining effect of subsequent beads is very apparent.

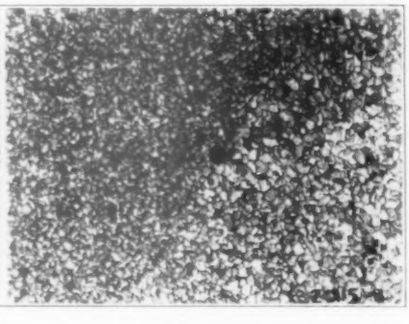


Fig. 7.

Section of arc weld taken mid-way in the weld showing weld metal on the right. 300X. The grain structure and size shown is typical of the entire weld exclusive of the last bead applied.

sisted in preventing any of the slag being trapped in the weld. As few interruptions as possible were permitted in applying each bead which was peened immediately upon completion and then wire brushed to thoroughly remove all scale.

The specimen as shown in Fig. 1 was made up accordingly. The flanges, originally designed for the service, were used to seal the ends of the tubing for test purposes. They also illustrate the relative size of a flanged joint and that made by welding. The specimen was subjected to a hydraulic pressure of 7,500 lbs. per square inch and each weld hammered. The pressure was increased to 10,000 lbs. per square inch and still showed no defects. It was then tested to destruction. The tube ruptured at an internal pressure of 28,600 lbs. per square inch. This gives a wall stress of 64,500 lbs. per square inch using the common formula and 82,500 lbs. per square inch using Clavarino's formula. The latter is probably nearer the actual wall stress.

The rupture extended along the axis of the tube about 5 inches and then forked at both ends. It was symmetrically located with respect to a circumferential weld which indicates that the rupture started in the weld, although examination with the "naked eye" did not disclose inclusions, noticeable crystalline structure except in the outer layer of the weld metal, or a poor bond between the weld metal and the parent metal; in fact, good homogeneity of structure seemed to be the case.

A second specimen made up exactly similar in every detail, but after the welder had become more familiar with the procedure, withstood a pressure of 31,000 lbs. per square inch without failure. As this is equivalent to the ultimate strength of the steel in the tubing, it is fair to conclude that the welded joints are satisfactory in every respect.

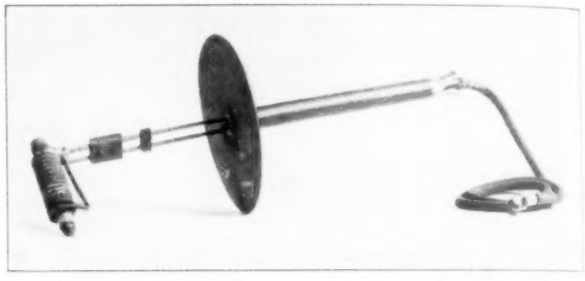
Electric Burning and Welding Tool

By A. M. MacFarland†

This tool was devised by the writer in 1925 for heavy carbon arc welding and burning. The device consists of a heavy carbon electrode mounted so that it will slide in a split steel tube. The tube is wrapped with several layers of asbestos paper, well gummed with sodium silicate (water-glass). The asbestos paper, thus impregnated to give it stability and hold it in position, serves as an insulated base for six or eight turns of small copper tubing ($\frac{1}{4}$"x$\frac{3}{16}$"). The tubing carries a water supply, brought in through the handle, and serves both to keep the carbon cool and to cool the entire holder. Light weight $\frac{1}{4}$" rubber hose is attached to the copper tube ends where they project from the handle. One line is attached to the nearest convenient service water supply, and the other line is carried far enough to discharge the circulating water as desired. A small stream of water is kept flowing at all times that the device is in use. In case no service water is available, a barrel of water and small circulating pump may be used.

The burning or welding current follows the tubing, magnetizing the central steel tube carrying the carbon. The magnetic field thus produced tends to blow the arc strongly from the point of the carbon, and both stabilizes the arc and gives it a strong directional effect. In fact the arc "blows" like the flame of an oxy-acetylene welding torch, and may be directed with the same precision. It may be held on a sharp corner of a steel bar, or used to burn holes of accurate dimensions in steel plate. It is very fast and effective for such cutting operations as cutting up old boilers or steel cars. One of its most useful applications is the burning off of rivet heads, preparatory to backing out the old rivets. Because of its powerful "blowing" effect, it may be used to cut alloy castings or steel plate lying in a horizontal position, and it will be found that the "blow" will keep the cut clean of fused metal ahead of the arc. It is applicable to any of the ordinary carbon welding jobs.

The assembly of the electrode holder is not particularly difficult. A 1½" fibre tube is used for the handle and a



Water Cooled Carbon Arc Welding and Cutting Tool.

1" steel tube wrapped in asbestos paper holds the carbon electrode. Wound around the carbon is a coil of $\frac{3}{16}$" I.D. copper tubing. The protective disc is 6" in diameter and preferably made of red fibre because molded materials are not apt to stand the heat. ¼" flexible rubber hose will serve to connect the water supply to the cooling system.

Because of its light weight and water cooled feature, it is convenient to handle and even when used with an 800 or even 1000 amp. arc, does not get too hot for the operator to handle.

Its disadvantages are the necessity for maintaining a constant water supply and its liability to damage from rough handling, or burning from accidentally touching the copper coils to the job, thus drawing an arc and burning the coil. This latter trouble may be avoided by covering the coils with a protective wrapping of asbestos tape. As the carbon burns away, it may be fed down further in the tube. A carbon thus water cooled will last about four times as long as one held in the ordinary carbon electrode holder.

The strength of the "blowing" effect may be regulated by varying the distance that the carbon projects from the end of the steel tube. A projecting end of about three inches will cut the stronger lines of the magnetic field and is a suitable adjustment for burning, as the arc will blow the fused metal out of the cut. A projection of four or five inches will reduce the blow to a point where the arc is stabilized and given direction without enough blow to disturb the fused metal, and is a suitable adjustment for welding.

Although the copper tube specified is very light for such heavy currents, it will carry a big overload because of the water cooling. Of course there is a certain loss of efficiency, but it is not of much consequence.

To make this tool fully effective and utilize the magnetic blowing to the fullest possible extent, the arc should

†*Welding Engineer, Youngstown Welding and Engineering Co., Youngstown, Ohio.*

have a considerable circuit voltage behind it. 60 or 70 volts is more satisfactory than less, because more blow may be utilized without extinguishing the arc.

A lot of twenty of these tools was made up by the writer in 1925, and several were used for cutting up old steel railroad cars. Some were used for welding steel motor frame rings.

The rings were rolled up from stock about three inches thick by ten inches wide into rings of about twenty inches diameter, leaving a gap about two inches wide between the ends, to be filled up by welding. It was a heavy, hot job and not very popular with the welders. Filler rods were placed in the gap and melted down with the carbon arc. The welder was using about 400 amps. with a one inch carbon. The entire length of the carbon would get red hot, and neither the carbon or the holder lasted long. Also, it was very uncomfortable for the welder. One of these new tools was put on the job and the amperage raised to 800. Several times more work was accomplished with less inconvenience to the operator, and a reduced consumption of carbon. The resultant weld was not of very high grade, but it served its purpose of bridging the gap with material that had some magnetic permeability. With the coated rods available today for "shielded" arc welding, this weld could be made clean and ductile. We would fill the gap with the $\frac{5}{16}$" rods, and puddle them down, probably making about three layers successively.

This tool forcibly illustrates the way in which an electric arc is responsive to the effect of a magnetic field, and how an arc may be magnetically controlled and directed.

Welders will find the study of this principle useful in their daily affairs, because a large percentage of their welding troubles are caused by magnetic blowing about of the arc.

A carefully studied arrangement of the ground connection will often balance the magnetic effects and stabilize an otherwise wild arc. The idea of using magnetic means for giving the arc direction is old, comparatively speaking, and it has been used for so long a time that it is not broadly patentable. It is now commonly used in automatic welding machines on high speed production work.

Although, as stated, the idea is old in principle, it has not been developed or utilized commercially to anything like the full extent of its possibilities. It still offers a promising field for inventors and experimenters.

Problems in Machine Welding

(*Continued from page 32*)

the following remarks will point the way to overcome the major difficulties encountered in machine welding operations. When machine design can be of a rugged form and the absolute minimum of operating cost may not be essential, control may be effected by restraint of movement in directions which might interfere with easy operation by the average shop operator. In this case the welding speed will be sacrificed and consumption of energy will be increased and very likely weld quality will also suffer, but the result may be all that is required for the particular use for which the product is intended.

Where more economical production is required it is desirable to construct machines so that forces are more or less unrestrained but controlled within close limits and by the use of carefully trained operators secure more economical results without sacrificing quality.

In this type of design control may be divided between the component parts of the machine and the method of applying and controlling heat absorption. In other words, given a reasonable opportunity the metal in the seam edges may be allowed to move naturally and the extent of the movement to be governed by the points, at which varying amounts of heat are applied while at the welding point, sufficient heat is applied to secure satisfactory welding conditions at the desired rate of speed.

Means may also be provided for mechanical control of material movement in combination with the automatic control through graduated heat and thereby secure more positive control at an additional initial cost in machine construction.

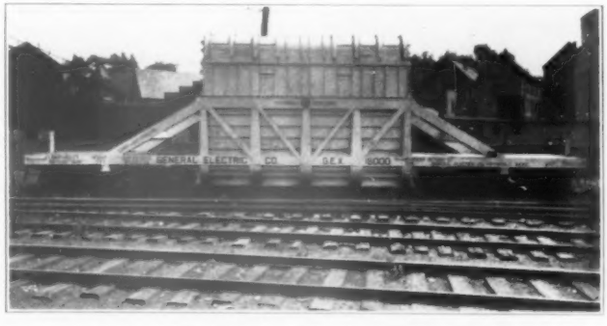
It is well to have in mind that the introduction of heat is oftentimes the most expensive part of the welding operation cost, and advantage should always be taken of the opportunity to bring the meeting edges or the parts of the seam to a welding heat with the minimum loss of heat either into the atmosphere or through conduction or otherwise into the machine or in any manner extract heat unnecessarily from the weld region.

In closing I would like to say that it is far more economical to employ large amounts of heat in a properly designed welding machine because the welding speed increases at a far greater rate than the heating medium consumption.

Welded Steel Transformer Car

A huge steel car, developed by General Electric engineers for the transportation of transformers, recently passed its first tests at the Schenectady Plant of the company. The new car, with the exception of the trucks, is of welded construction and marks a new departure in car design. It is estimated that over 5000 feet of welding were used in the assembly process.

For testing purposes, the car was loaded with 141 tons of pig iron, or approximately 11 tons in excess of its designed capacity. With this total load of about 52,750 pounds on each of its eight axles, the car was hauled over curves and grades. The load was then left in the car for some hours and tests were made for deflection in the springs and structural members.



Nearly a Mile of Welding in This New Type of Railroad Car.

The car, which is of unusual size, is 60 feet long and 10 and one-half feet in width. It is provided with two lifts, one of two feet, and the other of three and one-half feet. Its height above the rail, without either lift, is 10 feet. With the lifts, its height is 17 feet. The weight of the car alone is 141,000 pounds.

Building Up Worn Rail Joints

By Stuart Plumley†

THE welding of worn and battered rail joints has become a very necessary part of track maintenance in recent years. The saving accomplished is very considerable and figures in detail have been published from time to time in this connection.

Another interesting job of this kind is now proceeding on the main line of the Chicago, Milwaukee, St. Paul & Pacific Railroad, where this line extends westward from Minneapolis. The photographs shown were taken upon a section of track running east and west across the southern section of the city just before the railroad passes between the two beautiful city lakes, Calhoun and Lake of the Isles. This work is exceptionally well organized and is progressing rapidly westward along this section of track. There are thirty-five welders stretched out over about one mile of track, each welder having been assigned ten or fifteen rail joints which he reaches with long lengths of hose from oxygen and acetylene cylinders set at fixed points.

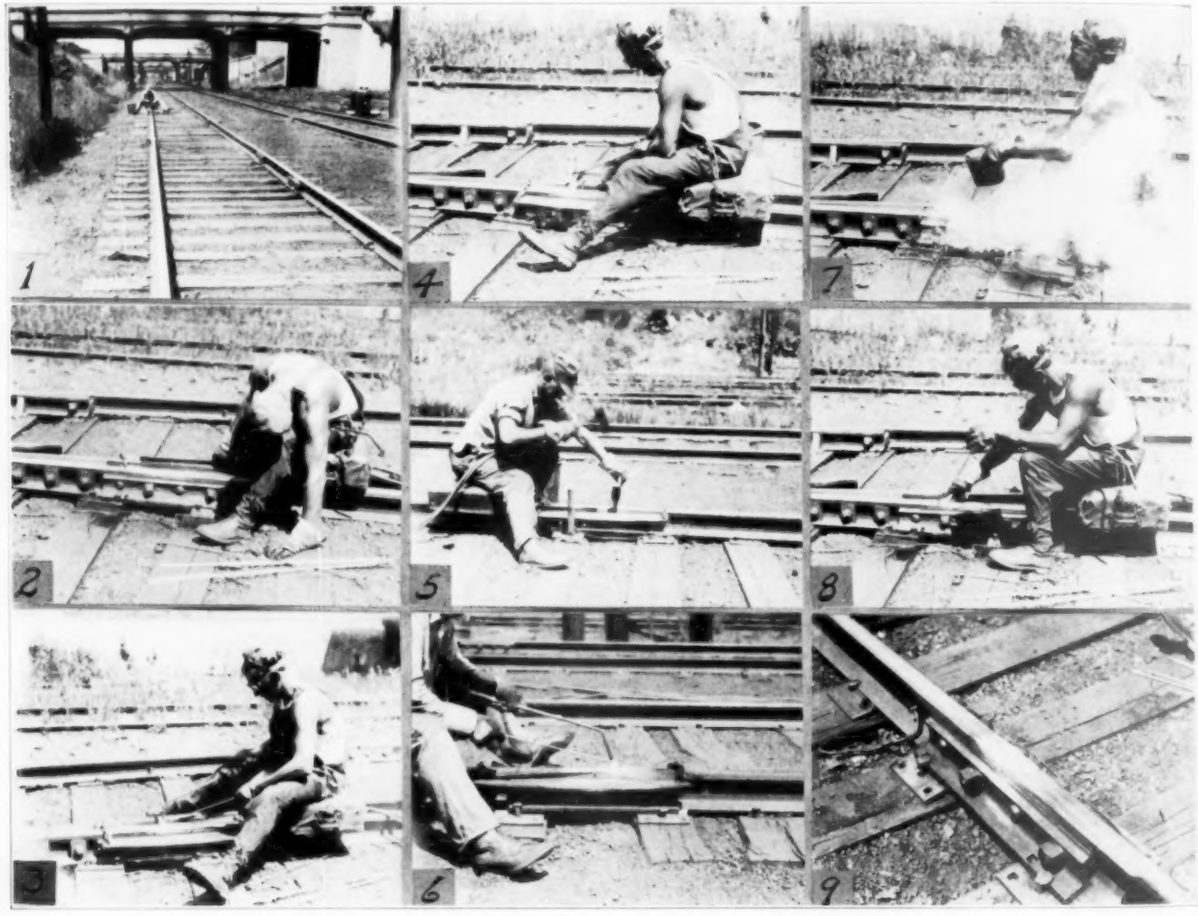


Figure 1—The welders are spread out over approximately a mile of track. Each welder is given from ten to fifteen joints to weld, depending upon his speed and experience.

Figure 2—Checking the rail to determine how much steel should be added. In some instances the rail joints are worn more than in others, but all of them are built up if they are worn to any extent.

Figure 3—When the rail is heated with the torch a small quantity of steel is added from the welding rod and the weld is hammered until smooth.

Figure 4—The process is really a combination of fusion welding and forge welding. A little metal is added with the torch, the weld and the surrounding rail head kept at the right temperature and the job hammered until smooth, square and true.

Figure 5—When welding has progressed to the actual joint between the two rails, the weld is carried on to the second rail and afterwards cut free with a cutter before the second weld is completed and while the weld is still red hot.

Figure 6—After cutting the weld between the rails free, the second rail is completed.

Figure 7—When welding is finished, the torch is used to reheat the finished job, if necessary, and the rail joint is then quenched with water from a dipper in which many holes have been punched in the bottom. Note the resultant steam surrounding the joint and the operator.

Figure 8—After quenching, the rail head is again heated until the temperature is approximately 650 degrees, or enough to melt the stick of solder which the operator is holding in contact with the rail head and turn it brown.

Figure 9—A view of the finished welded joint before grinding.

†*Chief Engineer, Smith Welding Equipment Corporation, Minneapolis, Minn.*

The torches and regulators used upon this work were manufactured by the Smith Welding Equipment Corporation and the oxygen and acetylene furnished by the Air Reduction Sales Company. No. 10 and No. 12 Smith's tips are used, depending upon the skill of the welder. If the operator has had considerable experience and can make a good weld rapidly, he is allowed to use a No. 12 tip, but if he has had less experience and is slower in welding, he is given a No. 10 tip. This recognition of the natural speed of a welder is excellent practice and takes into consideration important personal factors in the selection of men to do the best possible work upon a given job.

Both of these tips consume considerable gas per hour and for this reason two acetylene cylinders are manifolded together, to avoid too rapid discharge of one cylinder, and used in combination with one oxygen cylinder as the unit of gas supply. In Figure 1 these units can be seen distributed down the track together with drums of water for quenching. The men and equipment are spread along the track by a gasoline motor car hauling a train of small cars especially suited for the service.

The welding rods used are a special high carbon steel, having a carbon content which is somewhat higher than that of the rail itself. The practice is almost one of forge welding, because the steel is frequently hammered and this mechanical work upon the weld metal decreases the grain size and increases the strength of the weld. In Figure 2, the operator is checking the surface of the rail before welding to see how much steel must be added to build up the joint to its required level. He has welded the near rail of the frog and is about to start welding the far rail.

In Figure 3 a puddle has been made on the top of the rail and metal added from the welding rod. This metal is forged while hot, to required shape and smoothness, as indicated in Figure 4. The hammer is rapidly used while the torch maintains the necessary degree of heat in the rail head. This procedure continues; heating the steel head of the rail to fusion, adding weld metal from the welding rod; and forging with the hammer; until the full section of the head is built up. The weld is started at the beginning of the depression, or cup, as it is sometimes called, farthest away from the end of the rail. Welding and forging continues towards the end of the rail and when the actual joint is reached, the weld is carried on through to the next rail and proceeds to the end of the depression.

Before the joint between the two rails has cooled down, the weld is cut with a cutter, as shown in Figure 5. When the cut has been made, welding continues on the second rail, as shown in Figure 6.

When the second rail has been built up to its former shape and level, the joint is heated with the torch, if necessary, to a uniform heat and quenched with water, using a dipper perforated with holes in the bottom. The required degree of heat before quenching is approximately fifteen hundred degrees Fahr., which is well above the critical temperature for steel of this carbon content. Quenching continues until the rail has been cooled, so that the steam surrounding the joint and the welder, shown in Figure 7, ceases, or until the rail is approximately 212 degrees Fahr.

The torch is then again applied to the rail joint and the welded portion heated slowly and gently to a temperature approximately 650 degrees Fahr. This temperature can be determined by the color of melted solder applied to the top of the rail, as shown in Figure 8. In this photograph, the operator is wiping the stick of half and half solder across the top of the rail. If the streak of solder turns brown within two or three seconds, the temperature is close to 650 degrees Fahr. The joint is now allowed to air-cool, which means that the temper has been drawn to this temperature and the corresponding degree of hardness.

In Figure 9 the completed job is shown prior to grinding, which is accomplished with a grinding machine following up the welding crew. The joint is ground smooth and a vee-notch is ground thus chamfering the end of the rail at the joint.

Heating practice on this job closely follows the practice recommended for the heat treatment of rail ends to resist wear fully described by Mr. M. D. Bowen, Superintendent of Welding for the Milwaukee railroad, in an article published in Metal Progress for April, 1931.

Mr. Bowen has given much time and study to the perfection of welding practice in maintenance work, and is now in charge of this latest job of building up worn rail joints.

There is a lesson to be learned from this job, as is usually the case with most welding jobs and this lesson is the value of a thorough understanding of just what is to be done in the way of welding and heat treatment and careful and thorough organization of men and equipment to produce this purpose. Subsequent heat treatment of welds is not fully understood by many welders, and its use can be extended to many other classes of work requiring steel of a certain degree of strength and hardness upon the completion of the job.

Heavy Duty Truck Bodies For Hoover Dam Work

ONE of the principal jobs in connection with the construction of the Hoover Dam is the transporting of sand, earth, rock, boulders, and other rough and heavy bulk material. By reason of the extremely rough

Fig. 1. The Truck in Action.

and heavy material to be handled, and on account of the tremendous quantity to be moved, specifications were prepared and orders placed for a large number of extra

heavy all steel truck bodies and all-welded construction and heavy reinforcements were specified.

Figure 1 illustrates some of the punishment which these truck bodies receive in the work. The view was made inside one of the four large diversion tunnels which, when completed, are to carry the water of the river through the mountain side during the construction of the dam proper. These tunnels are each about 60 feet in diameter and are being bored and blasted through solid rock. The photograph shows a power shovel containing a load of huge rocks and sharp-edged boulders being dumped into one of these all-steel welded truck bodies. Note that the driver of the truck is safe from harm by falling rocks, etc., by reason of the cab of the truck body—also of steel—a part of the all-welded truck body, and an especially notable safety feature. Speed being necessary in this work, extra abuse is given these truck bodies. Were it not for the heavy steel material and their heavy welded construction, they would withstand this extreme abuse but a short time until they would be battered and shaken to pieces.

The construction of the bodies is of 6-inch channel iron and 4-inch H-columns for the main frame or chassis. The main longitudinal supports for the cross ribs are of two 6-inch channel irons welded together on both sides intermittently along the edges as seen in Figure 2, (bottom view) and the webs cut out and narrowed at the ends as shown. These longitudinal members were strengthened for side strains by specially shaped braces of ½-inch steel plate, and welded securely to the sides of the channels and to the H-columns forming the ribs, or main cross members of the body. These welded braces add much to the rigidity and strength of the body.

The sides and bottoms of the bodies forming the main shell are of $\frac{5}{16}$-inch steel plate, except that the bottom of the bed is of double plate construction with a wood center between the plates. The bottom plate of the bed is of ½-inch plate. The wood center for the bed aids in absorbing part of the jars and shocks caused by the falling of such heavy material.

The body shown in Figure 3 is 14 feet long and nine feet wide at the top. The bottom of the bed is six feet ten inches, and the capacity of this body is 14 yards. No end gates are used. Emptying is done by an elevating winch by means of a power take-off from the truck motor.

Separate sheets of steel were used for the sides, ends and bottoms, as can be noted by the welded seams at the edges. 3x3x¼-inch angle irons served for the top edge, or outside ridge of the bed, to which were welded the outside edges of the side plates. All edges of the plates were beveled before welding, one heavy bead being considered sufficient in most cases. Continuous welds were made on the shell, or bed, of the body on the inside, while intermittent welds of about six inches in length and the same distance apart were staggered in the welding to the four-inch H-columns, or rib irons.

In the bottom of the bed at the front end, were welded 3x3-inch angle iron to reinforce the end edges of the plates and prevent unevenness and buckling. Four 4-inch strips ½-inch in thickness as strengtheners to prevent further buckling in the bottoms were welded lengthwise to the bottom plate.

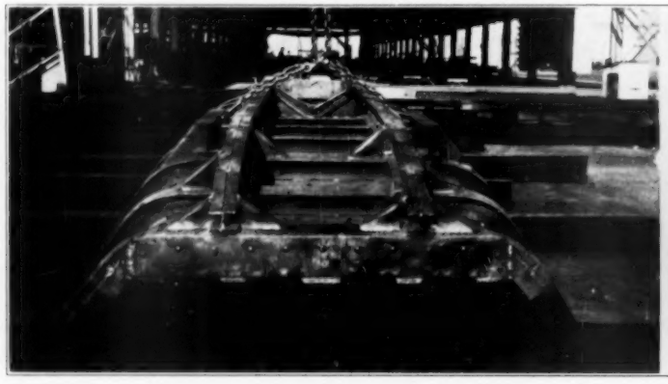


Fig. 2. Bottom View of Truck Body.

Fig. 3. Top View.

The cab for the body, made of ¼-inch plate, cut and pressed to shape and welded to the front end of the body, provides a safety feature for the truck driver, as mentioned above. ⅜-inch corner protective plates about ten inches wide and two feet long were welded at the front end corners of the truck body as added protection to the side of the body in entering and leaving the tunnels, etc.

All of the welding on these truck bodies was done by the electric arc process, using principally Lincoln "Fleetweld" coated rods. $\frac{7}{32}$-inch and ¼-inch rods were used principally in the welding.

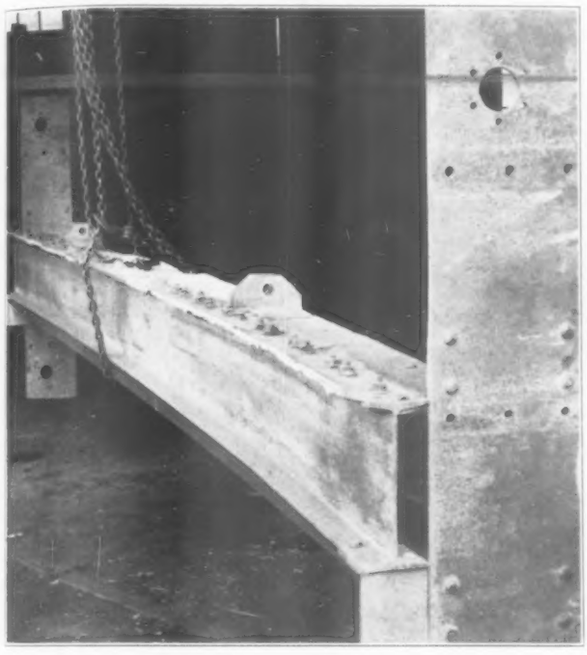
The Consolidated Steel Corporation, of Los Angeles, was awarded the contract for the fabrication and delivery of about 60 of these unusually heavy truck bodies, which range in size from eight to fourteen yards capacity. The bodies were built entirely in the welding department of the steel company's plant on East Slauson Avenue in the Central Manufacturing District of East Los Angeles. The construction of the bodies was under the direction of G. J. Carroll, plant superintendent, assisted by J. B. McClellan, in charge of shop fabrication and welding operations. Thanks is hereby extended to this company for the courtesy of permission to make and publish the accompanying photos.

Shrinkage Used to Shape Grade Board

Welding played an important part in the construction of a part described by R. G. Wilson, District Manager of Burdett Oxygen Co., Atlanta, Georgia. This was a grade board for paving highways that was repaired recently by the Ellis Garage and Machine Shop at Griffin, Georgia. The grade board is used by highway pavers to drag along the surface during the concrete pouring in order to get the proper curve on the road bed. It is evident, therefore, that the arch in this board must be exactly true. It was

constructed of a twelve-inch I-beam eighteen feet long and had two $\frac{3}{16}$-inch by 9-inch strips welded on each side, the full length. The purpose of these strips was to obtain the arch and insure the rigidity of the piece.

To get some picture of the problem of taking care of the stresses it is interesting to note that the beam itself sagged one quarter of an inch under its own weight before



Just Enough Shrinkage to Produce the Required Arch.

welding the strips in place, so it is evident that the strain set up in the welds was what caused the rigidity. The method used by Mr. Ellis to obtain his two and one-half inch arch in the beam was to start in the center of the beam and weld two feet in each direction on all welds. The welds were allowed to cool and then two feet welded in each direction again and the work allowed to cool again as before. This process was continued until the job was completed and the welding process was found to have set up a strain in the beam that exactly made a two and one-half inch arch.

When completed the board was set up unsupported except at the ends and was tested with a three and one-half ton weight in the center and was found to be absolutely rigid.

French Engineer Studies Manual Automatic Welding

THE editors recently received an interesting account of studies made by Jean Brillie, Research Engineer of La Soudure Autogene Francaise, Paris, France, concerning an arc welding method which he refers to as "manual automatic arc welding." This study paralleled the development of a covered electrode called "SAFER 351" and consists essentially in letting the electrode maintain natural contact with the parent metal instead of being held freely in the air at a distance during the welding period. The principal claims for this method are regularity in welding speed, the appearance of the bead and the quality of the deposited metal. It is claimed that the process is as easy in the vertical and overhead positions as in the flat position, due to the fact that the arc length is maintained automatically constant and is determined by the depth of the crater formed by the covering, the speed of welding being determined by the speed of fusion, which depends only on the current density. Among the conclusions arrived at as a result of this study are: First, the arc is shorter and more stable in this process than in ordinary arc welding; second, for a given current adjustment, the speed of welding is notably independent of the angle of the electrode with the work; third, the speed of fusion of the electrode is proportional to the current; fourth, the width of the deposit is proportional to the current; fifth, the average height of the deposit is inversely proportional to the current; sixth, the speed of welding is consequently not necessarily proportional to the speed of fusion of the electrode; seventh, the most advantageous current adjustment corresponds to a weld deposit practically equal to the length of the electrode melted; eighth, at this regulation, the length of the bead being practically equal to the length of the electrode, the section of the bead will therefore be practically equal to that of the electrode allowing for small losses by fusion. This makes it possible to note from the section of the bevel the number of beads which will be necessary to fill it according to the diameter of the electrodes used.

In his investigation of this procedure, Mr. Brillie has gone carefully into detail, using recording meters to show the voltage changes with this method as compared to those with ordinary arc welding, and preparing charts to show the relation between the current used, the melting rate, the dimensions of the deposit and the rate of advancement, at the same time tabulating these values carefully.

Welded Steel Garage

Fire, earthquake and burglar proof—reasonable in first cost as well as upkeep—this new arc welded steel garage being erected by Hobart Brothers Company of Troy, Ohio. It presents interesting possibilities of extent of application of arc welding to garage and residential construction.

Construction Which Assures Permanence for the Garage.

Shaped, hollow metal roof construction will be used, giving insulation from heat and cold, and the same side wall construction will be used, giving an outside as well as inside smooth finished surface.

Modernizing for Profit

Greater speed is only one of the advantages gained by bringing the resistance welding equipment up to date. The improved product may have an easier or a wider market, thus reducing the sales cost. The trend toward automatic control is growing because of this fact.

Better Production and Better Welds

By Walter A. Anderson†

EVER since the first resistance welding machine was put into operation, the story of this production method has been a story of steady improvement. Engineers devoting their talents to the design of resistance welding machines have treated limitations of the process as problems of design and have solved these problems one by one in rapid succession, thereby increasing the applications of electric resistance welding on a large scale from year to year. This continuous work on design has increased our knowledge of the fundamentals of resistance welding and of its possibilities. However, for the manufacturer of metal articles it is still more important that research and experiment in the field of design has continued with its usual vigor during the past two or three years of low industrial activity, paving the way for better production, better welds and new applications in future years.

In view of this progress, it seems obvious that the manufacturing plant using old resistance welding equipment will be operating at a disadvantage in the coming year as compared to plants having thoroughly up-to-date equipment. Even some of the machines made two or three years ago can easily be out-classed in performance by more up-to-date models. The following discussion is intended to show some of the ways in which present resistance welding operations can be modernized and more profitable results obtained.

The first thing to consider is the noticeable trend toward the use of automatic welders. This is being found advantageous even in the cases where production is not continuous. For example, one concern in northern Michigan recently purchased a new automatic type of machine. Their work at best will give them only a few hours' production daily on any one item, but the setup time is so short that it is insignificant compared to the advantages obtained by automatic operation. It is well-known that practically all of the spot welders purchased by automobile and automobile body makers are automatic except in rare cases where the job actually demands manual operation. The same holds true of many other groups of manufacturers who use resistance welding.

The advantages of automatic operation, therefore, deserve consideration. One of the most important is the elimination of operator fatigue. This means that production is maintained at a high level all day long and the operators are better satisfied. These factors are important to the purchaser of welding equipment, and in addition there are the possibilities of more uniform welds, faster operation, better welds, smoother welds, lower current consumption and longer electrode life. The labor cost is reduced to some extent by the increased speed of production and again by the fact that unskilled labor can be used to a greater degree.

Taking all of these advantages into consideration and assuming that the welder can be kept busy several hours a day, it has been demonstrated that the difference in initial cost between a manual and an automatic spot welder can be made up in a few weeks' time. After that the savings show up as increased profit.

Galvanized iron, terne plate, brass, copper and aluminum alloys can be efficiently welded only on automatic welders. The word "efficiently" is used because a number of manufacturers are welding these metals on manually operated machines, but the results are not uniform and they induce an element of doubt into any product. It is recognized that some jobs demand manual operation, but it is seldom that the welder manufacturer finds a case where automatics could not be used with some degree of improvement or economy.

In a recent comparative test in an automobile body plant, an automatic welder equipped with Elkonite points was found to have the following advantages over a foot operated welder of similar capacity, also equipped with Elkonite points:

First: Produced 40,560 welds before point dressing

†*Vice-President, in Charge of Sales, Taylor-Winfield Corporation, Warren, Ohio.*

was necessary, as against 10,330 welds on the foot operated machine.

Second: 33% greater production.

Third: Smoother welds.

Fourth: Better welds.

Fifth: More uniform welds.

Using ordinary copper points, the foot-operated machine made 3,000 welds before redressing was necessary. Using the above figures for comparison, the automatic type would make 12,000 welds with copper points before dressing.

The second method suggested for modernizing of resistance welding equipment is the possibility of rebuilding. Old models can often be improved in this manner. Our own organization has made a careful study of this possibility and has found that in numerous cases where the user cannot afford to scrap his old equipment and buy new models, it is a sound investment for him to have certain alterations made to improve the efficiency of his present equipment. When such equipment is received at the factory, it is first completely disassembled and thoroughly cleaned. All worn or broken parts are replaced. If necessary, the transformers are restacked and rewound. Frequently the secondary voltage is stepped up so as to give snappier action, which is so necessary to fast spot and flash welding.

Then there are what might be called "special developments in design" to be considered. Some of these center around problems encountered due to special shapes which users want to weld and some due to materials which have presented welding difficulties to the manufacturer. One of the latest developments of our plant is called the "Synchromatic Welder" which was developed for spot welding non-ferrous metals and stainless steels. Resistance welding engineers have recognized for a long time that for the welding of aluminum, Duralumin and similar non-ferrous or composite metals and stainless steel, a very accurate control of all welding elements is necessary to assure uniform high strength of welds and retain chemical properties of the metal.

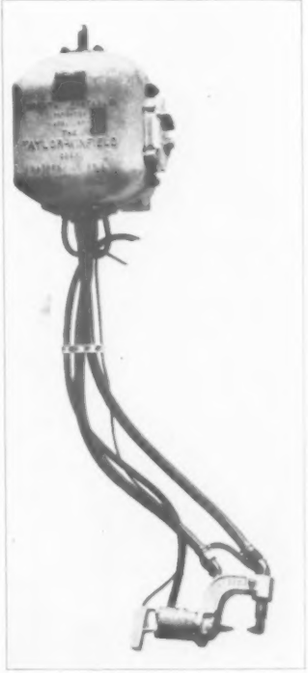


Fig. 1. Portable Spot Welder with Synchromatic Control. It Is Air Operated.

In the case of the stainless steels, it has been noticed that spot welds made in the ordinary way are somewhat discolored, indicating improper control of heat. The chemical action due to a combination of carbon and chromium destroys the stainless qualities of the steel and leaves the spot subject to what is called intergranular corrosion.

The new machine mentioned above is equipped with what is termed a synchromatic control. The purpose of this device is to furnish a commercially perfect uniformity of control over the quantity and duration of heat. The contactor is driven by a synchronous motor through suitable mechanical apparatus to produce welds at the rate of 180 per minute, with a dwell time of only a small fraction of a second. The contacts are closed and opened at the zero value of the current which assures accuracy and eliminates variations due to the duration of arcing. It has been found, in fact, that with the synchronized contactor there is no appreciable arcing and therefore no burning of the contact surfaces. The air valve which controls the air cylinder is driven by the control device, which synchronizes the pressure with the heat and thus prevents any possibility of burning the spot due to faulty pressure application.

Fig. 1 shows the Taylor-Winfield "Moesta" synchromatic air-operated, portable spot welder which utilizes this ingenious current control. It has a new type of air operated head arranged in such a way that the position of the handle and yoke can be altered to suit the convenience of the operator and the type of work being welded, and many forms of yokes and electrodes can be attached. It is suitable for welding two thicknesses of 1/8-in. stock. It can also be used on ordinary sheet steel work to excellent advantage where a minimum amount of discoloration and indentation is desired.

Fig. 2 is a view of the mechanism of the synchromatic control. It consists essentially of a synchronous motor-driven cam shaft from which is operated the necessary parts to make a complete automatic and accurately timed welding operation. The present minimum dwell time is

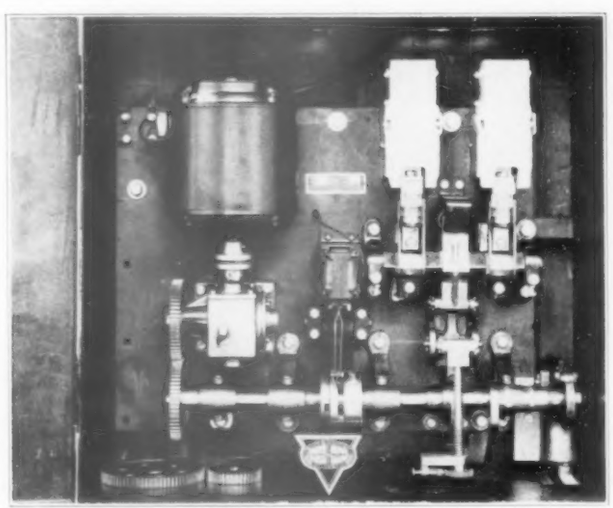


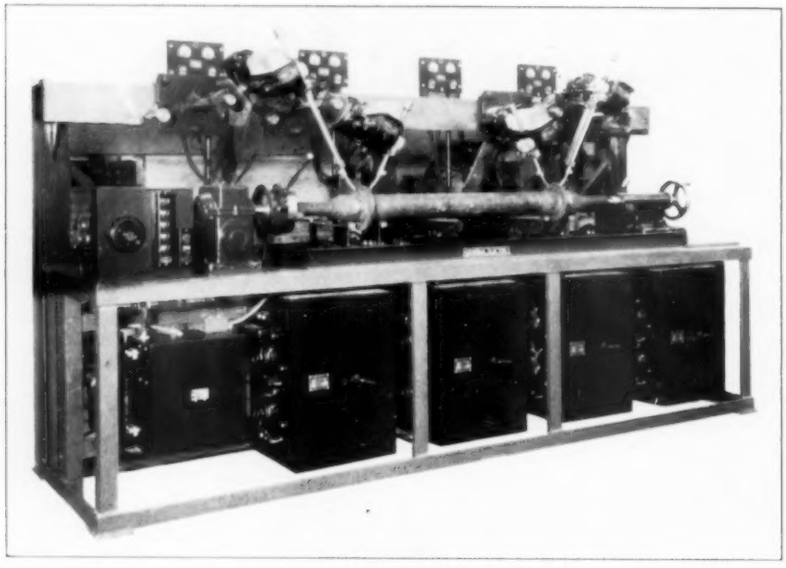
Fig. 2. Close Up of Mechanism in the Control Cabinet.

three cycles, or 1/20 of a second. Changes can be made to reduce this time to lower values if it appears desirable.

To tell the complete story of what is being done to modernize resistance welding operations, it would be necessary to continue describing, one after another, the various machines, attachments and special parts which have been designed by welding manufacturers to improve production in specific applications. The one striking fact which stands out is that in this field increased speed has not been detrimental to the results obtained. In practically all cases where the production rate has improved, better welds have also been secured. This means addition savings in inspection, in materials and in replacements on account of failures. It is no wonder that the public is beginning to accept welded construction as the most up-to-date and satisfactory kind of construction.

Tubular Trailer Axles

One of the outstanding developments in motor transportation in the last year is the increasing use of trailers. The greater payloads and high road speeds demanded have necessitated definite improvements in economy and safety. The Timken-Detroit Axle Company has introduced a line of brake-equipped trailer axle in a complete range of capacities to meet modern trailer operating conditions. In order to obtain the strongest axle beam to make it capable of withstanding the braking torque, and the most rigid beam which is necessary to insure maximum tire life, without increased axle weight, a tubular axle design was developed.



Automatic Arc Welding Machine for Trailer Dead-axle Spring Pads and Flanges. Front View with Axle in Place.

The tubular sections range in diameter from three and three-quarters inches to six inches, with wall thicknesses of one-half and nine-sixteenths of an inch, and the lengths vary between 60 and 94 inches. In order to obtain full advantages of the Timken design, modern developments in automatic electric welding were employed. Spring seats and brake flanges are welded to the tubular axle beam.

The Timken-Detroit Axle Company, after exhaustive tests, adopted the automatic arc welding process for the welding of the brake flanges and spring pads to the axle. The welding machine, which was furnished by the General Electric Company, has four automatic arc welding heads, each of which is mounted on a roller bearing carriage, allowing it to be quickly positioned for either the flanges or spring pads on any length or size of axle. When the start button is pressed, the four arcs are automatically established and instantly the travel motor starts to revolve the axle, which is mounted between centers. In this way, a uniform, deep-penetrating weld is made on each side of the flanges or spring pads. By means of an adjustable synchronous timing relay, the equipment is automatically stopped at the completion of the weld. Each welding head obtains its current from an individual General Electric type WD-24, 400-ampere arc welding set. General Electric type L welding electrode is used. The illustration above is a front view of the equipment ready for production with the tubular axle in place.

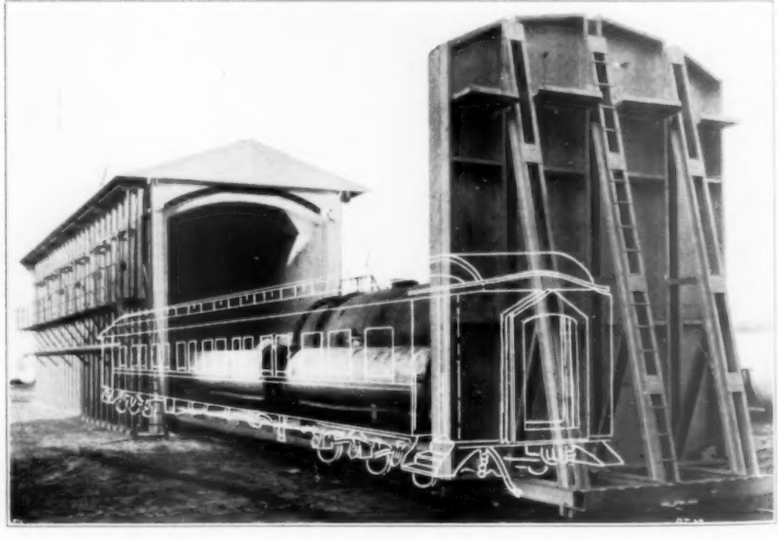
Repairing Blow Torches and Gas-Tank Pig-Tails

By R. R. Shuman.

Welding and cutting torches in some services are continually making trips to the repair shop. Much of this trouble is due to inexcusable abuse at the hands of operators, who seem not to hesitate to use a torch as a hammer when the spirit so moves them. In the early days, standard practice in torch repair work was to re-braze the joints with spelter or brass welding rod. Later, as the original joints in more and more makes of torches were brazed by their manufacturers with silver solders fusing at 1500 to 1600° F., it became out of the question to do repair brazing with spelter or brass alloys requiring 1600 to 1800 degrees of heat. Silver solders of a lower melting point than those used in the manufacture of the torches then became necessary to the torch repair man.

But, recently, a new brazing alloy made by Handy & Harman, "the silver solder people," has come into use. This new alloy is called "Sil-Fos" and melts at 1300° F. The silver, phosphorus and copper in the alloy combine to give a remarkably free-flowing property which insures deep and instant penetration at a brazing temperature which is not destructive to the original joints and connections in the torch. Large torch users, such as bridge and structural iron workers, shipbuilders, railroads, pipe-line contractors, etc., are now using "Sil-Fos" for their torch repair work. It is

(*Continued on page 47*)



Oven Could Cook a Pullman Car

In an article appearing in the August issue of The Welding Engineer, describing the annealing oven used by the American Tank & Equipment Corporation, Oklahoma City, Okla., it was neglected to state that that company is a subsidiary of Black, Sivalls & Bryson, Inc., formerly of Bartlesville, Okla., and now located in Oklahoma City, and that this oven was designed and built by the company's own engineers. The fact that this oven will accommodate a vessel 12 ft. in diameter and 77 ft. in length is well illustrated by the accompanying photograph. This is just about the size of a Pullman car. This heat treating oven is but one of the factors for greater efficiency and safety produced and used by this enormous plant, in which the well-known B S & B "Flex-welding" process has been developed.

REPAIRING BLOW TORCHES
(*Continued from page* 46)

also used for insuring the leak-tightness of the pig-tails, and other connections in acetylene or other pressure tanks. Though containing a small percentage of silver, "Sil-Fos" is sold by the pound (instead of by the troy ounce, as are silver solders) at prices that make it available for economical production and repair work.

Correction

In an article appearing in the August issue of The Welding Engineer by Mr. R. M. Shimkin, on the subject of "All Welded Gasoline Truck Tanks", mention should have been made of the fact that all of the tanks mentioned in the article had been designed by Mr. Shimkin for the California Steel Products Company and built by them.

Booklet on Repair Welding

Under the title "Repairing for Profit," a new booklet has just been issued by The Linde Air Products Company, New York. This publication contains two articles that are of interest to every automotive repair shop owner. The first article "Oxy-Acetylene Welding in Automotive Repair," points out in considerable detail six fundamental operations performed in repairing and maintaining automotive parts. The process of bronze-welding is described as to methods and procedure and several typical examples are cited. "Welding with Rod of Similar Composition to the Base Metal" is a second section of this article which discusses methods and procedures for welding with steel welding rod, welding cast aluminum and sheet aluminum. Other interesting sections cover lead welding, soldering, heating, special applications, body repairs, tanks, and jigs and fixtures. A feature of this article is a "Welding Analysis of Automotive Parts" in tabular form. Essential parts are classified and listed, the usual metal compositions of the parts are indicated in corresponding columns, and adjoining these is shown the recommended welding method used for maintenance and repair.

In the second section of the booklet a detailed sales promotional campaign is outlined. The campaign is broken down into twelve variations so that it is suitable for any type of shop in any location.

Discusses Hard Facing Farm Tools

Under the title "Modern Tillage," the Stoody Company of Whittier, Calif., has published a seven-page booklet dealing with the application of hard facing materials to plows and other agricultural equipment. An interesting feature of the booklet is a portion of the introduction which explains the self-sharpening effect when hard facing is applied to such parts as scarifier teeth. There is also included a list of about twenty parts of farm equipment on which hard facing applications are said to be profitable.

Use of Nickel-Clad Steel

Lukens Steel Company of Coatesville, Penn., has published an eight-page bulletin illustrating many new and interesting applications of nickel clad steel. These applications include tank cars, tank trucks and trailers, hot water heaters, evaporators, chemical mixers, hoppers, kettles and a large variety of tanks. These containers, with their protective linings of nickel, resisting the corrosion of processing solutions and compounds, are finding a market in a great variety of industries, and the bulletin with its excellent photographs show that there are practically unlimited possibilities in design for the use of this recently developed plate material.

Stainless Steel Tubing Is Welded

The Carpenter Steel Company of New York City have just published a folder featuring their line of welded stainless steel tubing. Although this is the first literature which they have issued on the subject, the manufacture of welded stainless tubing is really not a new development, as several years have been devoted to it. This tubing is made from cold rolled stainless steel, both the insides and outside surfaces of the tube representing surface metal from the original ingot. The weld is made automatically under exact control and is scarcely distinguishable from the rest of the tube either physically or chemically. The tubing is produced in round, square and rectangular shapes and also in some special shapes. It is stated that it is easily welded by either the oxy-acetylene or electric arc process.

Hobart Book on "Simplified" Arc Welding

As a companion piece to their popular Manual of Electric Arc Welding, which has required three printings to meet the demand, Hobart Brothers Co., Troy, Ohio, have produced a new book on "Simplified" Arc Welding and its many uses. This new manual is specially interesting because of its many action photographs as well as the subject matter. It discusses applications of electric arc welding to the problems of factories, continuous process plants, and other users of extensive mechanical equipment. Railway, oil field, and general job welding earnings and savings are also covered by interesting text and photographs. The latter portion of the book is given over to complete description of the new Hobart Diverter Pole Arc Welder in the various types and sizes available. Beginning with the "Triple Economy" Model, this line is shown available with either electric motor or gasoline engine driving power and in belt or coupling driven units of compact design. Auxiliary generators for operating grinders and other electric tools are also available with the gasoline engine driven models.

Bulletin Describes "Shield-Arc" Welder

An eight-page bulletin has just been published by the Lincoln Electric Company, Cleveland, Ohio, featuring the new "Shield-Arc" welder which was recently announced in these columns. The bulletin discusses the electrical characteristics of the new machine and the performance which may be expected of it. Special attention is given to such details as control cabinet, various control devices, the design of the magnetic circuit and the drip proof construction of the machine itself.

Quasi-Arc Electrodes for Wear Resisting

Bulletins now being distributed by Quasi-Arc, Incorporated, New York, describe the properties of two new electrode materials in the Quasi-Arc line. One of these is the "H & T" electrode for depositing metal on machine tools which can be ground to a cutting edge. These electrodes are made in gauges from 12 to 6 and are supplied in bundles of 25. The manufacturers state that they have passed satisfactory laboratory and practical tests which show that the weld metal is highly resistant to abrasive stresses and shock. It is therefore recommended for tipping tools or parts of machinery which have to withstand exceptionally heavy duty or which have to resist deformation under heavy stresses. Among the latter applications are oil well drilling tools, rock drills, dies, etc.

A second bulletin describes the "Mangcross" electrode for welding manganese steel and for reinforcing manganese steel, carbon steel, mild steel, etc., with a metal having a high resistance to wear. It is stated that the metal deposited is an Austenitic steel, tough and comparatively soft, but rapidly wear hardens when subjected to abrasion or hammering. Photographs show its application to dredger bucket lips and carbon steel rails. There is also illustrated a method of fabricating railway crossings from standard rail by welding with this electrode.

Along with the introduction of these special electrodes there has been issued an announcement of considerable reductions in prices of all electrodes in the Quasi-Arc line.

Unique Spot Welder for Filaments

A spot welding machine that is capable of welding 1000 units per minute has been designed, built and is in operation at the C. H. Q. Laboratories of Glendale, California. The machine is designed primarily to weld the segments composing the lead-in wires for radio tubes and electric light globes. The welder is the only one of its kind in existence, according to C. H. Q. officials, and required more than two years to build. Some 40,000 parts are included in the completed machine which has more than 1000 ball races. The auto-

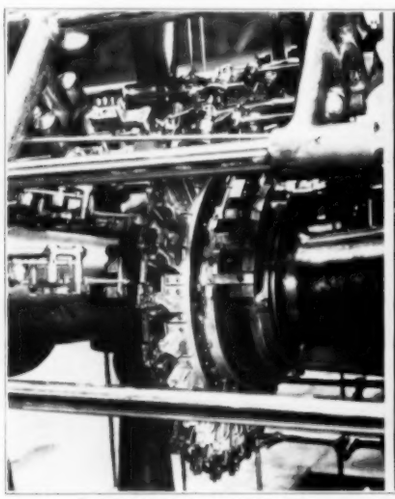
matic welding machine weighs 6½ tons.

Lead-in wires are used to feed the filaments inside radio tubes and electric globes. Each lead-in is, in reality not a single wire, but three different segments welded into a unit. The portion of the wire that leads outside the tube to which connection is made with the service wire, is composed of ordinary copper. The segment about which the glass standard inside each tube is fused, is an alloy. This alloy must have the same coefficient of expansion as the glass, otherwise air leaks would occur, destroying or greatly decreasing the efficiency of the tube. The portion supporting the filament proper is usually of nickel. Nickel is used because it has been found in actual laboratory tests to give off less obnoxious radiation under heat than any commonly available metal.

The turret seen in one of the pictures is 24 inches in diameter. In it are enclosed the electric wires carrying the current for operating the machine and supplying the amperage to the welding points. Rolls of wire are automatically carried to this rotor, each segment being cut off at its proper length, and fed to clasps which carry the segments to the fusing spot. When the segments are in position they are instantly fused by means of an electric arc. The machine has capacity of from 50 to 2000 microfarads which means it is able to arc-weld wires of almost microscopic fineness or those of a diameter of a quarter of an inch. Four welds are made at one time.

This machine completely does away with hand welding. This was essential because the impact of the human hand or body upon the sensitive lead-in wires often causes pyrotechnics inside the tubes, rendering them worthless. It was even discovered that mechanics, coming in from lunch and going to work without first washing their hands, could produce a large portion of non-usable filaments and lead-in wires. No human hands touch the wires in this new process of automatic spot welding.

The welder is the invention of Mr. C. H. Quackenbush, president of the C. H. Q. Securities Corp., of Cleveland, Ohio, and Glendale, Calif. Mr. Quackenbush is a well known inventor and engineer, having to his credit a number of patents for automatic machinery used in various industries.



Turret of the Automatic Welder Which Can Make 1000 Spot Welds Per Minute.

A Handful of Welded Lead-in Wires. In Each One Three Segments Are Welded Together.

Bronze Electrode Requires No Flux

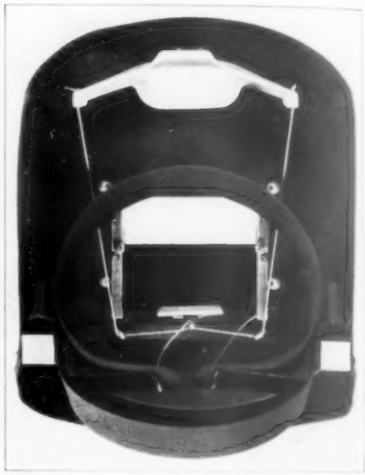
Whelite special bronze electrodes, recently announced by Whelite Distributors, Los Angeles, Calif., require no flux and have no coating. It is stated by the manufacturers that the fluxing materials are incorporated into the metal when it is melted. The purpose of the specially processed materials is to prevent oxidation so as to secure a deposit free from weak spots and gas pockets. This rod is specially recommended for electric welding of cast iron without the use of preheating or application of flux. About 25 to 35 volts and 100 to 115 amperes with reverse polarity is the recommended technique. It is necessary to hold a close arc and incline the rod in the same direction in which the bead is carried. The tensile strength of these electrodes is given as 59,313. It is stated that the rod can be used also for oxy-acetylene welding and that in this application no flux is required.

Lincoln "Weld-Fast" Head Shield

A welding operator's head shield, designed to increase production by raising the operator's efficiency, is announced by The Lincoln Electric Company, Cleveland, Ohio. This new type shield, known as the "Weld-Fast" Head Shield, embodies a movable protective lens which allows the operator clear vision without raising the shield. Thus both hands are free at all times and welding can progress with few interruptions. The protective lens is held in place in a vertical slide by a spring; slight pressure with the chin on an aluminum rest raises the lens and allows the operator to view the work or change electrodes. When pressure is removed, the lens automatically falls back into place. A stationary cover glass guards the inner lens against spatter and also protects the operator from flying sparks in case the movable lens is accidentally raised.

In order to keep the weight of the shield at a minimum, aluminum is used for the case enclosing the glasses and sturdy featherweight fibre for all other parts.

The sides of the "Weld-Fast" shield are brought well back and close to the head, preventing flashes from other operators. The front curves inward to assist in protecting the chin. An adjustable headband assures the operator of complete comfort while wearing the shield. There is sufficient room in the shield to allow the operator to wear eye glasses or spectacles without interference.

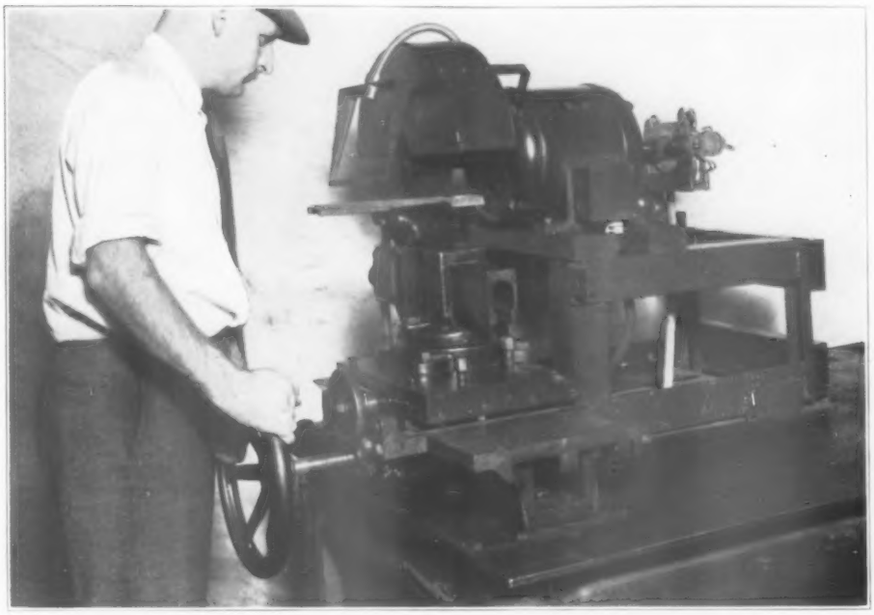


Lincoln "Weld-Fast" Head Shield.

Scratch Extensometer by Baldwin-Southwark

The Scratch Extensometer developed by Baldwin-Southwark Corporation, Philadelphia, Pa., and shown in the accompanying photograph weighs less than an ounce, is hardly larger than a teaspoon, may be attached to light as well as heavy structures, and is recording. It records tension-compression strains and, also, when tension-compression strain is present, will record shear strain. It is necessary to make a special adaptation when pure shear strain alone is to be recorded. It should be further

The Scratch Extensometer.



Now You Can
CUT ELECTRICALLY

With the Electric Arc Cutting Saw, the cutting wheel is one electrode and the work to be cut is the other. Several hundred amperes at a low voltage pass between the cutting wheel and the work, the wheel revolving and continuously presenting a cool surface to the work. The wheel, instead of wearing out, gradually increases in diameter, making it necessary to shave the wheel from time to time. A steel wheel is used for cutting mild steel, and carbon, carborundum or copper alloy wheels for other alloys. Can be attached to any welder, but an alternating current welder and high speed drive are preferable for best results. Any one with an arc welder can cut with this apparatus under a license from our company, or the machine with transformer complete may be had from us. With it you can cut many sizes and shapes which formerly had to be cut by slower and more expensive methods.

Write for complete details about this latest development.

The Electric Arc Cutting Saw can be purchased in connection with any ALTERNARC welder or with the DUBLARC which operates two Electrodes at the same time with the following advantages:

1. One man handles both arcs with one hand.
2. This doubles the speed of deposition.
3. This doubles the power factor and increases the efficiency all around.

Electric Arc Cutting & Welding Co.
Newark, N. J.

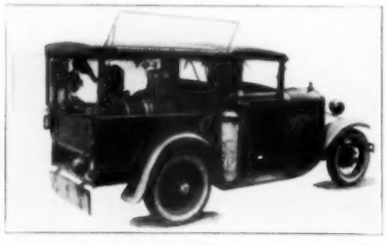
explained that with strain known and with the Modulus of Elasticity known it is a very simple matter to evaluate stress. The lightness of the instrument permits the application of many of these devices to a given structure for simultaneous determination of stresses.

Champion Announces Welding Rod Line

After forty years of making rivets, The Champion Rivet Company, Cleveland, Ohio, are announcing a new line of general purpose welding rods. Recognizing the fact that welding as a process has definitely made scientific progress, The Champion Rivet Company announce this radical addition to their line in order to give their customers a complete metal joining service. While the Champion Rivet Company will still continue to market their rivets, their sales organization will have with it a line of welding rods to offer. Officials of the company state that several years of experimenting are behind this new line of welding rods.

Power Take-Off for Portable Welding Shop

C. E. Phillips & Co., 5443 Twelfth St., Detroit, Mich., is marketing the Bourque power take-off with which the Ford



Completely Equipped for Gas or Electric Welding.

pick-up car, shown in the accompanying photograph, is equipped. The welding generator is operated by the motor of the car through the power take-off, as well as an additional generator for the operation of electric grinders, drills, etc. The photograph shows a complete welding shop on wheels, and such an outfit enables the owner to tackle almost any kind of a job within motoring distance of the shop.

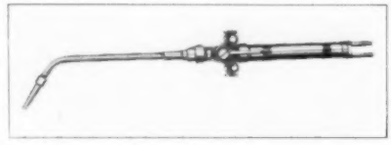
Weld Rod for White Metal

Scientific Welding Manufacturing Co., 508 Fay St., Utica, N. Y., has placed on the market the S-W "white metal" welding rod for the welding of die-casting materials, such as small machine parts, carburetors, radiator caps, vacuum cleaner and washing machine parts, auto door handles, etc.

The rod is claimed to be free-flowing and welds are readily machined; it is stated that a satisfactory weld can be made by anyone experienced in the use of the welding torch by simply following the instructions accompanying the rod. The rod is available in two-pound packages. It is also said to make a satisfactory hard aluminum solder.

Y & M Welding Torch

A new welding torch recently announced by Y & M Torch Company, Compton, Cal., is equipped with a special valve which has two sets of needle valves, permitting the adjustment of any two separate and distinct flames and a complete shut-off by a thumb control lever attached to the mas-



New Y and M Welding Torch.

ter valve without closing the needle valves. The thumb control lever may be moved from one position to another, giving the operator either flame desired instantly. After closing the master valve when relighting the torch, the same flames previously used are secured without further adjustment of the needle valves, according to the manufacturers. A descriptive circular of this new torch has just been published.

New Protected Arc Electrode by Hollup

Hollup Corporation, Chicago, recently put on the market a new electrode of the protected arc type to which they have given the name "Sureweld." This wire has been produced especially to meet the requirements of the various welding codes. The claims made for it are high strength and ductility, high specific gravity, sound weld metal, and complete protection of the molten metal while passing through the arc and while solidifying. The slag is easily removed. The makers state that this electrode can be used equally well at extreme speeds with high currents and for difficult work with low currents, and that it can be used easily in all welding positions. It is packed in 50-lb. lots, in welded sheet metal containers. This electrode is used with reverse polarity, and each container carries instructions as to the proper current adjustment for different sizes of electrodes and different thicknesses of material.

Hobart Appoints Anderson in Philadelphia

The Hobart Brothers Co., Troy, Ohio, announce the appointment of Dorsey C. Anderson as Central Atlantic Distributor for Hobart "Simplified" Arc Welders, with headquarters at 847-C Terminal Commerce Building, 401 N. Broad St., Philadelphia, Pa. Mr. Anderson is surrounding himself with an organization of welding specialists and experts and is himself well qualified to serve the trade in connection with welding equipment. He is well and favorably known in the territory and has been connected with the welding industry for 21 years, having been District Sales Manager for the Lincoln Electric Company for 15 years. In addition to the Hobart "Simplified" Welding line, Mr. Anderson and his associates are prepared to offer the trade a complete welding service, including welding rods and supplies of all kinds.

Welding Clinic Held at Elgin, Illinois

Under the auspices of the Barrett Hardware Company, Joliet, Ill., distributors of Rego welding and cutting equipment, a Welding Clinic was held at Elgin, Ill., the evening of September 9th. C. J. Shaw, general manager of the Barrett Hardware Company, opened the program with a talk on the distributor's position in the welding equipment industry. H. O. T. Ridlon, of the same company, followed with a general talk on welding and its applications in repair work, and also factory maintenance and production. Special emphasis was placed on the selection of proper equipment and materials for the work and the proper care of equipment so as to produce better welds. Four reels of motion pictures were shown. Then followed a talk by Jack Menzies, of the Stoody Company, on hard surfacing and a demonstration of hard surfacing farm equipment. The meeting started at seven o'clock and broke up at eleven-thirty, at which time refreshments were served to the visitors, who numbered nearly one hundred.

G. E. Tenney Heads Lincoln Chicago Office

Appointment of G. E. Tenney as sales manager of the Chicago district, is announced by The Lincoln Electric Company, Cleveland, Ohio.

Previous to joining the sales staff of the Lincoln organization, Mr. Tenney was engaged in shop, engineering and sales work for the Houghton Elevator Company, Toledo; The Recording & Computing Machine Company, Dayton, and the Moore Drop Forging Company, Springfield, Mass. For the last three of his nine years' service with the latter company, he served in the capacity of sales manager.

Mr. Tenney, a graduate engineer from Ohio State University, interlarded his engineering work with four years' service on the Mexican border, the Philippines and the Orient with the United States Army. At present he is a major in the Reserve Corps.

NEWS OF THE INDUSTRY

W. D. Scheffey, with headquarters at Syracuse, N. Y., has become affiliated with the Bannar Welding Supply Co., Buffalo, N. Y., in a sales capacity. The company distributes Burke arc welders, Champion electrodes, and Air Reduction oxy-acetylene apparatus.

W. G. Millen has sold his interest in Iowa Falls Machine Works, Iowa Falls, Ia., to his partner, W. E. Lyon, and has purchased the business and equipment of Crabb Engine Co., Independence, Ia. A welding department will be added.

Richey-Flickinger-Barrett Co., Marshall Bldg., Cleveland, Ohio, have incorporated the Ohio Welding Co., to operate a welding business.

J. P. Morrissey, of The Crucible Steel Company of America, will talk on "The Welding of Stainless Steels," at a meeting of the American Welding Society, Philadelphia Section, to be held Monday evening, September 19, at the Engineers' Club, 1317 Spruce St., Philadelphia.

C. J. Holslag, of the Electric Arc Cutting & Welding Co., Newark, N. J., has been spending several weeks in the Presbyterian Hospital following an accidental injury while he was vacationing at Brant Lake.

The Iowa Falls Machine Works, machining and welding, Iowa Falls, Ia., has passed into the hands of W. E. Lyon, who has purchased interests of W. G. Millen, his partner for 13 years.

The Welded Products Co., of Bell, Cal., recently acquired the Conley Plastering Co., who were manufacturing an all welded machine for applying plaster and cement by a mechanical process.

Stanley Hensley, former partner of S. F. Bradford in the Owl Welding Works, Los Angeles, California, is now associated with the Reliable Welding Works, at 1522 East Ninth St., in Los Angeles. Lawrence Tuttle was owner and manager of the Reliable shop prior to the new arrangement.

The Arc Welding Corporation, at 2376 East 51st St., Los Angeles, Cal., was recently organized and has opened for business under the joint sponsorship of F. H. Asbury, president; Joe P. Richardson, vice-president, and L. G. Frick, as secretary and general manager.

The Alco Products, Inc., of Tulsa, Okla., fabricators of welded oil refinery equipment, has been awarded a contract for the installation of two oil refinery units for the Argentine government in its refinery at La Plata, in the province of Buenos Aires.

Roy Thomas, of The Torch Shop, Los Angeles, Cal., is being issued an additional patent on the Rego-Thomas torch. The improvement covered by the new patent is the flash arresting feature. New production equipment is being added in the shop.

T. C. Skeen, of the Columbian Steel Tank Company, Kansas City, Mo., manufacturers of all-welded storage tanks, recently made a business trip for his company to the East Texas Oil fields. This concern has also recently entered the field of building portable steel houses for summer homes, industrial warehouses, etc.

The Vernon Power Company, Los Angeles, Cal., have awarded a contract to the Consolidated Steel Corporation for the construction of ten large steel furnace stacks and ten steel waste heat boilers.

Twenty-two miles of acetylene welded 8-inch gas line is being laid by the Santa Maria Gas Company between the cities of Santa Maria and Pismo Beach, Cal.

A new oil field service and job welding shop, to be known as the Acme Welding Works, was recently opened for business in the Signal Hill oil field of California. Bill Hooper is owner and manager of the new shop which is located at 2748 Cherry Ave.

The Consolidated Steel Corporation, Los Angeles, Cal., was recently awarded a $240,000 contract for the construction of the huge steel bulkhead and stoney gates for use in the water diversion canals of the Hoover Dam project.

The Chicago Bridge & Iron Works has been awarded the contract for the construction of four large welded steel gas holders for the Southern Counties Gas Company, Los Angeles, Cal.

C. E. Larson, formerly welding engineer with the Aluminum Company of America, New Kensington, Pa., resigned his position to become a junior partner in the firm of Wooldridge & Larson, contractors for welding, plumbing, heating and air conditioning at Glastonbury, Conn.

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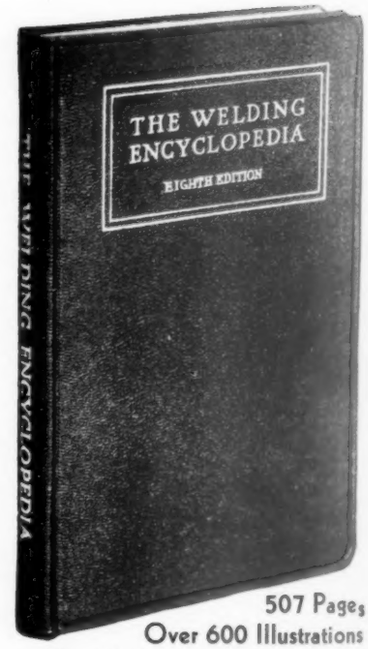

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